SAE Journal

DECEMBER 1952

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

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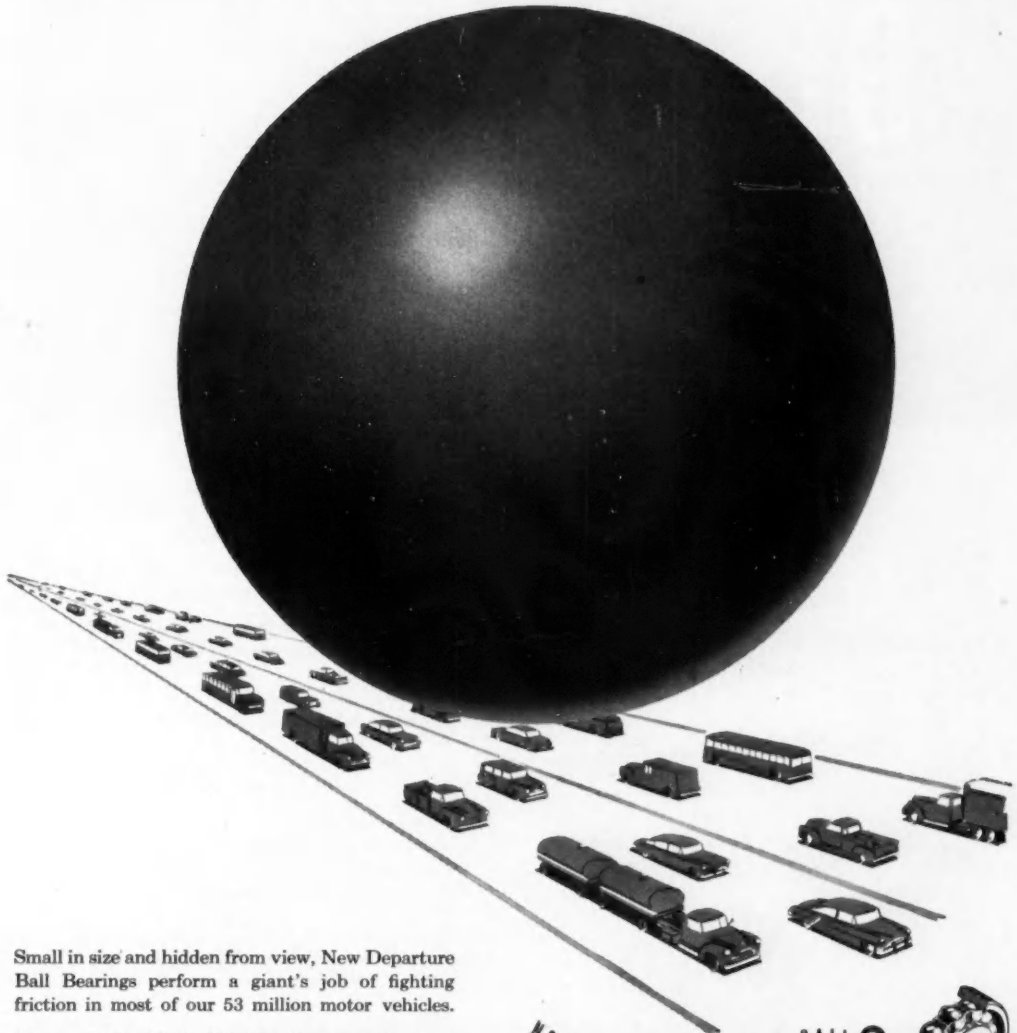

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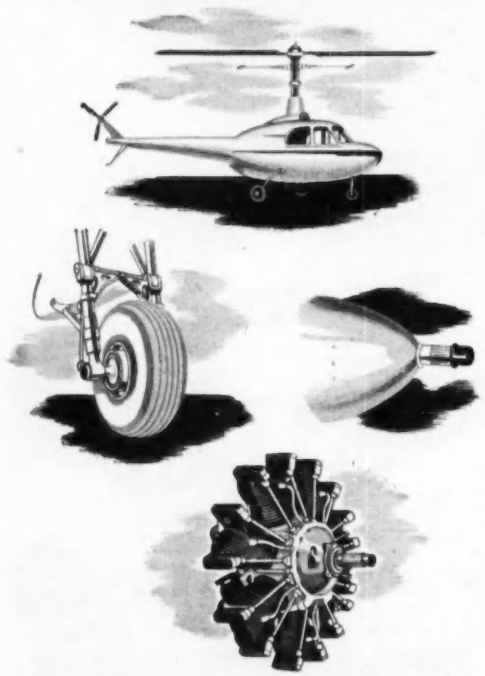

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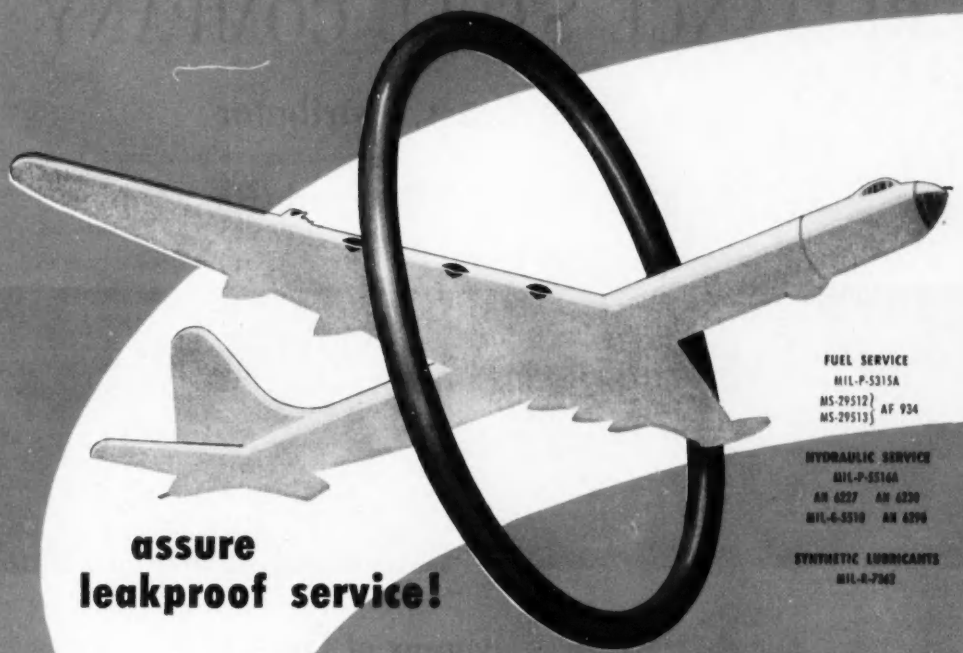

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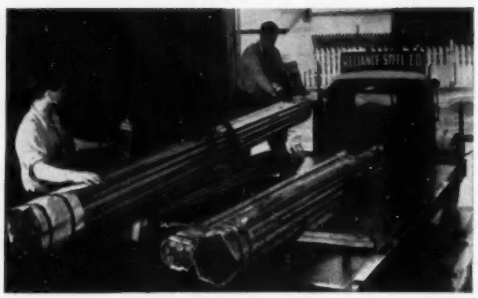

The Reliance Steel Company of Los Angeles now has available a complete line of Dow Magnesium sheet, plate and extrusions.

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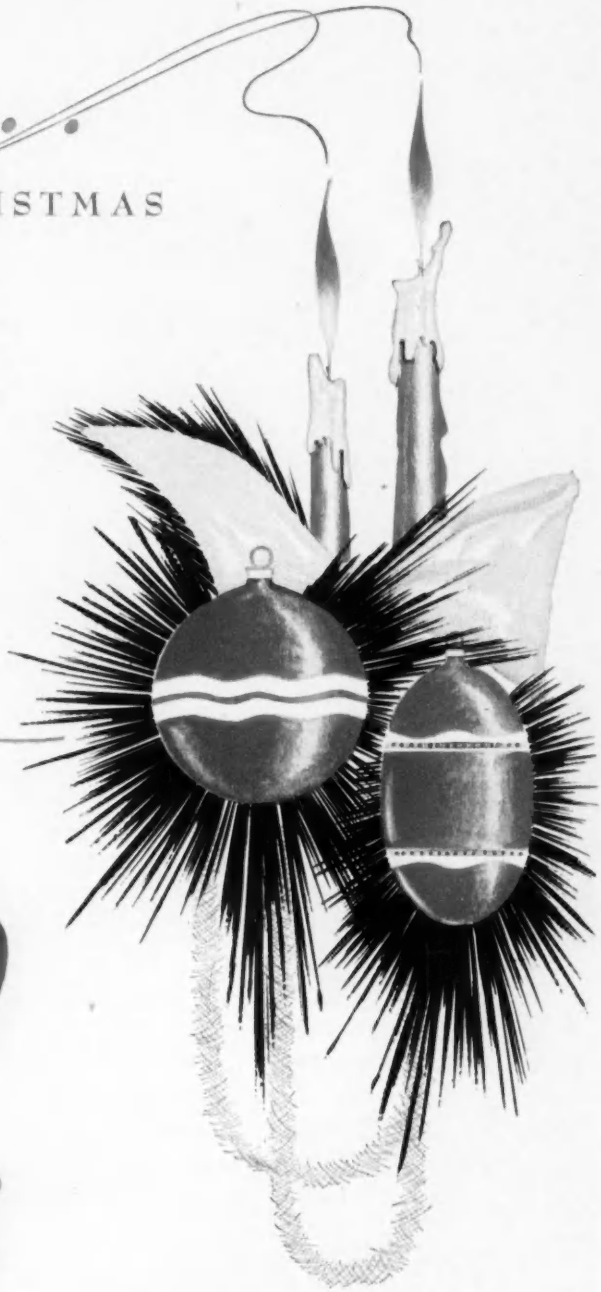
that we shall continue
to merit your goodwill
in the years to come.

To You and Yours . . .

Merry Christmas



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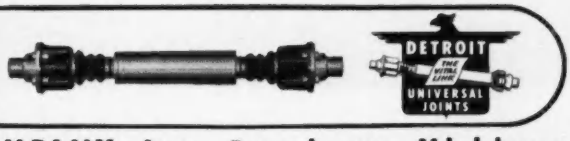

UNIVERSAL PRODUCTS COMPANY, Inc., Dearborn, Michigan

Du Pont Petroleum Research

reports new findings on the basic precombustion reactions underlying the occurrence of knock

HIGH compression engines are increasing the need for fuels having greater knock resistance. And since production of such fuels is becoming more costly, a better understanding of the knock process and discovery of improved means for its control are of considerable importance.

With the future needs of the petroleum industry in mind, the Du Pont Petroleum Laboratory is intensively studying the basic chemical reactions which lead to knock. From this program it is believed that information will be obtained which will help in designing new improved fuels and lead to the more efficient utilization of present fuels.

The tendency of a fuel-air mixture to knock is determined by the extent and type of precombustion reactions occurring in the unburned charge ahead of the flame front. And the build-up of knock-producing materials depends to a considerable extent on the chemical composition of the fuel, but is influenced by the ratio of hydrocarbon to oxygen and the time allowed for the reactions to take place.

MOTORED ENGINE USED IN STUDIES

In the studies, the effects of changes in fuel-air ratio and engine speed on the complex precombustion reactions of several different types of hydrocarbons were examined so as to gain a clearer insight into the nature of these reactions.

Precombustion reactions were initiated by compressing the fuel-air mixtures in a motored engine. The physical conditions under which they occurred were determined. Since this technique substitutes compression of the unburned charge by the piston for compression of the end gas by the flame front, the problem of isolating the proknock reactions is simplified greatly. The engine was equipped with a quartz window and a photoelectric tube in order to detect the faint radiation which signals the presence of a cool flame. The radiation detected by this tube was amplified 40 million times and the resultant output applied to an oscilloscope screen.

OXIDATION A TWO-STAGE PROCESS

Most hydrocarbons oxidize by a two-stage process. The first consists of the early hydrocarbon oxidation reactions which lead to the formation of a cool flame. The second stage is accompanied by a cool flame and persists in a motored engine until autoignition of the charge takes place. In general, changes in the mixture ratio entering the engine were found to affect both the first and second stages of the fuel oxidation process.

An increase in the fuel-air ratio inhibits the early hydrocarbon oxidation reactions, requiring higher temperatures and pressures for the initiation of cool flames. The autoignition tendencies of the hydrocarbons usually are suppressed by increases in fuel-air ratio, although a minimum in the conditions required for autoignition often is evident close to the stoichiometric fuel-air ratio. These effects on autoignition are very similar to the effects of fuel-air ratio on the trace knock limits of fuels in fired engines.

NATURE OF THE CHEMICAL REACTION

Information as to the nature of the chemical reactions involved in both stages of the precombustion reaction process was obtained by a study of the effect on these reactions of two different types of chain reaction inhibitors—nitrogen and tetraethyl lead. Nitrogen was found to retard principally the first stage of the reaction, while tetraethyl lead was effective largely in slowing the cool flame reaction. This behavior indicates important differences in the two reaction phases leading to knock.

NATURE OF THE PHYSICAL REACTION

From a physical standpoint knock results when the end gas in an engine cylinder is stressed to a critical temperature and pressure for a sufficient time. The effect of this time factor has been investigated by determining the cool flame and autoignition limits

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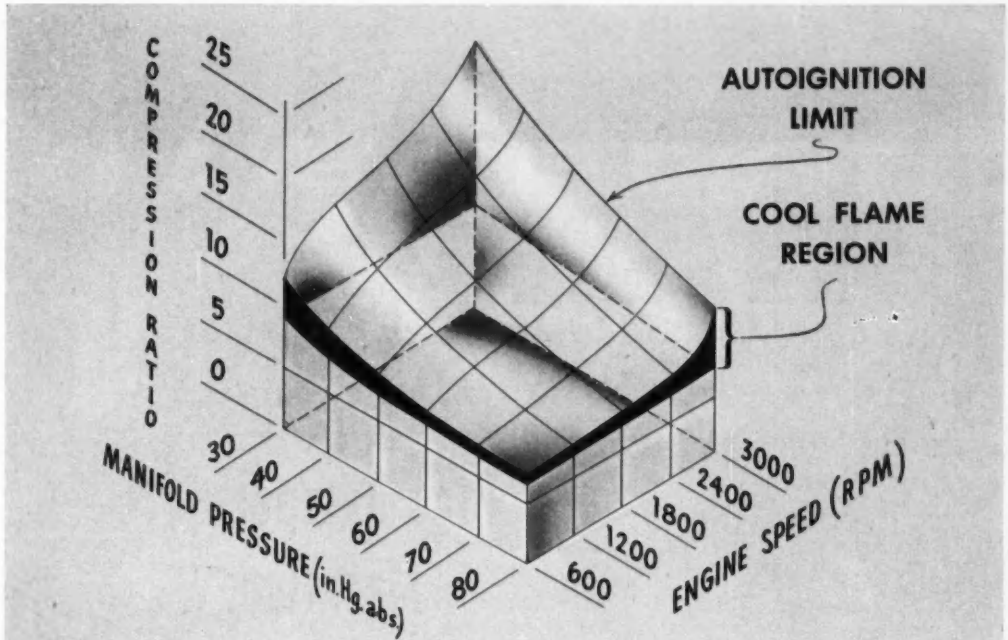

COOL FLAME AND AUTOIGNITION LIMITS OF ISOOCTANE

of hydrocarbons at different engine speeds. The lower cool flame limit did not appear to be affected by engine speed. But the conditions required for autoignition became more severe as engine speed was increased.

The information obtained in this study clearly shows the effects of the three fundamental variables controlling knock—pressure, temperature, and time—on the ignition behavior of a hydrocarbon. The effects of these variables when isooctane is used as the fuel are shown in the chart above.

TEMPERATURE SENSITIVITY OF HYDROCARBONS

A study of the effects of pressure and temperature on their autoignition limits has provided a measure of the absolute temperature sensitivity of hydrocarbons. Many hydrocarbons were found to change markedly in temperature sensitivity as engine conditions were changed; even heptane, which is assigned a sensitivity of zero, is quite temperature sensitive under some conditions. The difference in temperature sensitivity of two hydrocarbons, as measured by the standard rating procedure, was explained by a method in which end gas temperature-pressure paths for fired engine cycles under Motor and Research Method rating conditions were superimposed on the autoignition limits of the hydrocarbons at 600 and 900 rpm.

This work on precombustion reactions is part of a continuing research program at the Du Pont Petroleum Laboratory. Since Du Pont is a major supplier of tetraethyl lead and other gasoline additives, the aim of this program is to help refiners improve fuel performance through the use of additives.

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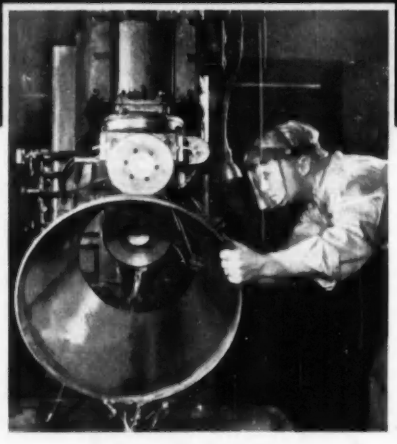

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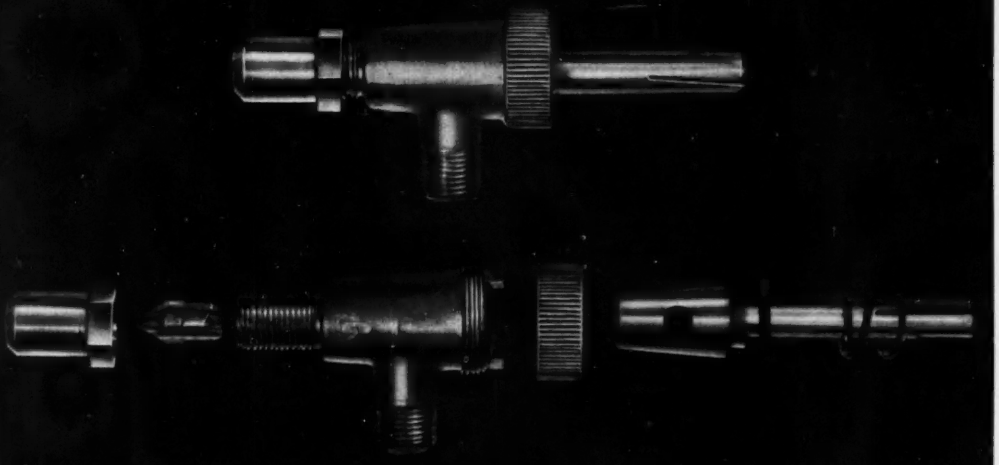

Kitchen range burner valve by Lincoln Brass Works, Inc., Detroit 16, Mich. Two different brasses are used in this valve, which is entirely of brass except for the washer and spring. Lincoln also makes valves for heaters and furnaces; flow, drain and shut-off valves for gasoline lines; shut-off valves for agricultural sprayers, and a wide variety of tube and pipe fittings, all entirely or chiefly of free-cutting brass rod and free-machining brass forgings.

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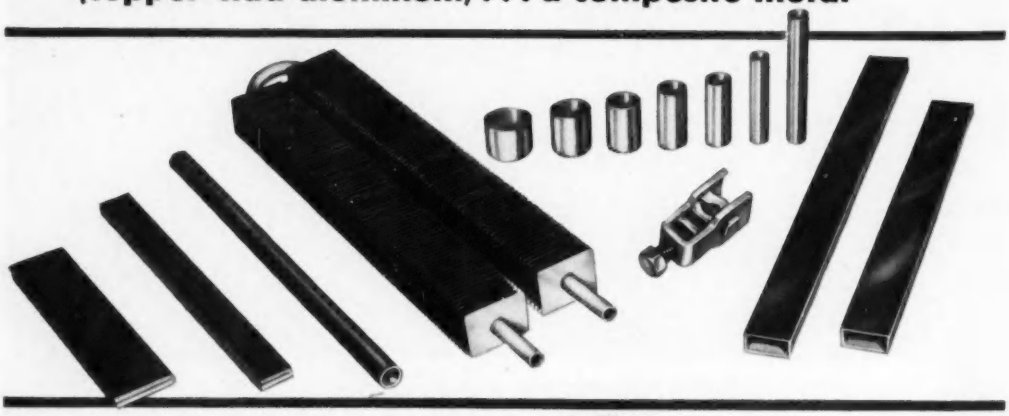

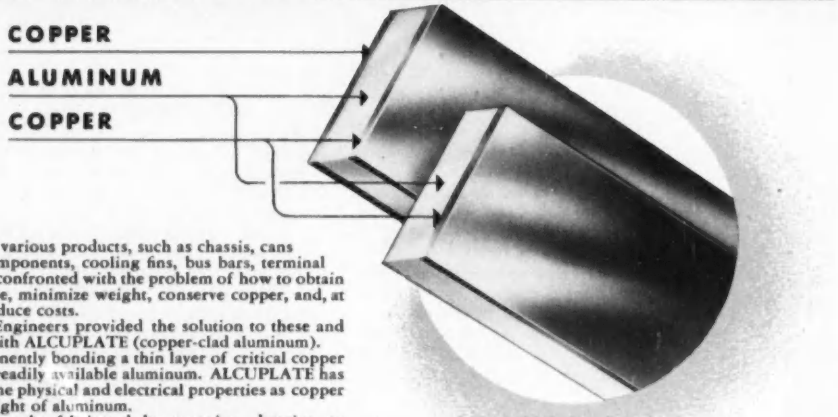

Enlarged Drawing of Alcuplate

Manufacturers of various products, such as chassis, cans for electronic components, cooling fins, bus bars, terminal connectors were confronted with the problem of how to obtain good performance, minimize weight, conserve copper, and, at the same time, reduce costs.

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ALCUPLATE can be fabricated by stamping, drawing or forming. Its malleability permits its use in the manufacture of many parts from work-hardened rather than annealed or dead soft materials. The copper provides an ideal surface for soft soldering or electroplating.

ALCUPLATE is widely used in the electrical and electronic fields for terminals, clips, shims, small motor housings, electronic component cases, brackets, and electronic wave guide tubing. It may also be used for heat transfer assemblies, fin and tube type radiators, printed circuits, costume jewelry and similar applications.

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For the Sake of Argument

Principles Can Help . . .

By Norman G. Shidle

The man who sees specific cases as examples of a principle-in-action is likely to go far. He will outstrip his fellow who sees each problem or solution as isolated. That's often the difference between a successful executive and a mediocre one.

The principle-seer forms mental patterns. These stand him in good stead when he is forced to think about abstractions. Principles form a liaison between the specific and the general.

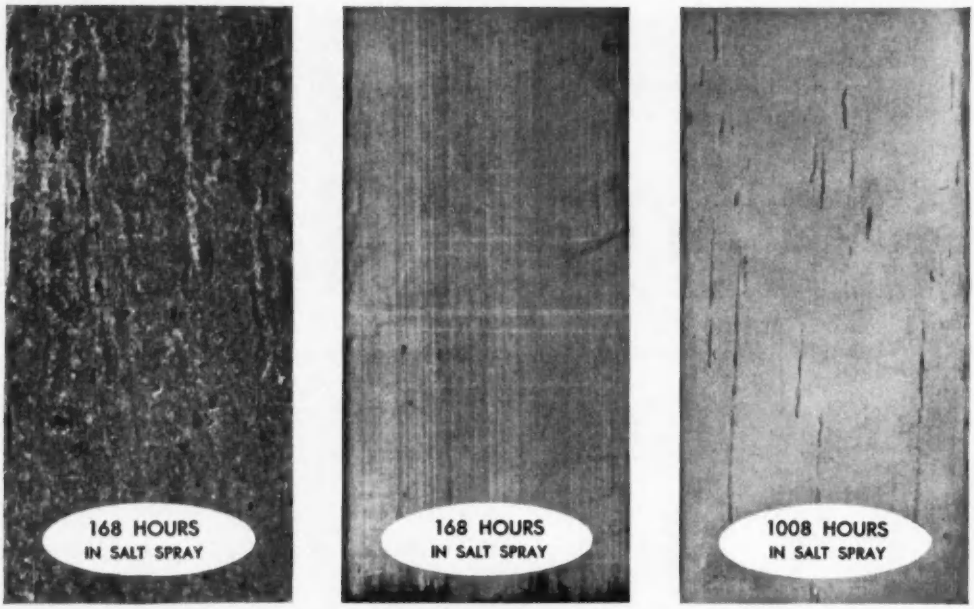
Many people can deal readily with one special case after another. The ability to work comfortably with ideas and the relationship between ideas is not as common. It's easier for most folks to work with what they can see, than with abstractions. So, "practically everything made or built by man was first a picture in someone's mind," as noted in a recent Rogers & Slade bulletin. "One reason that so many people cannot deal in ideas," the bulletin continues, "is that abstractions are seldom picturable."

Yet, the most difficult and basic questions man faces are abstractions. None of the eternal realities can be seen or felt or smelled. In everyday business life, right use of a sound principle brings more lasting effects than application of a single test result.

Principles can take the place of pictures in dealing with our more complex problems. They can be a bridge for the mind between the abstractions which are so hard and the pictures which are so easy. Principles are sort of focused abstractions.

Principles are specially important to engineers. As Leighton Wilkie says: "No man's mind is capable of mastering all that has been learned in the realm of the several sciences in this hundred-year period of phenomenal expansion. But man has the capacity to understand principles."

Seeing things as examples of a principle helps to keep opinions from running away with judgment. The expert —whom William Feather calls "a man who knows where to find the answers"—usually turns to a principle when faced with a tough decision.



SALT SPRAY TESTS SHOW CORROSION RESISTANCE

Panel of bare 24ST Aluminum, untreated. Extensive corrosion after 168 hours in salt spray.

Panel of bare 24ST Aluminum, treated with Bonderite 710. No corrosion after 168 hours in salt spray.

Panel of bare 24ST Aluminum, treated with Bonderite 710. In excellent condition after 1008 hours in salt spray.

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A SALUTE TO

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on its 100th anniversary

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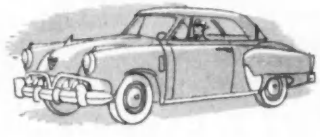

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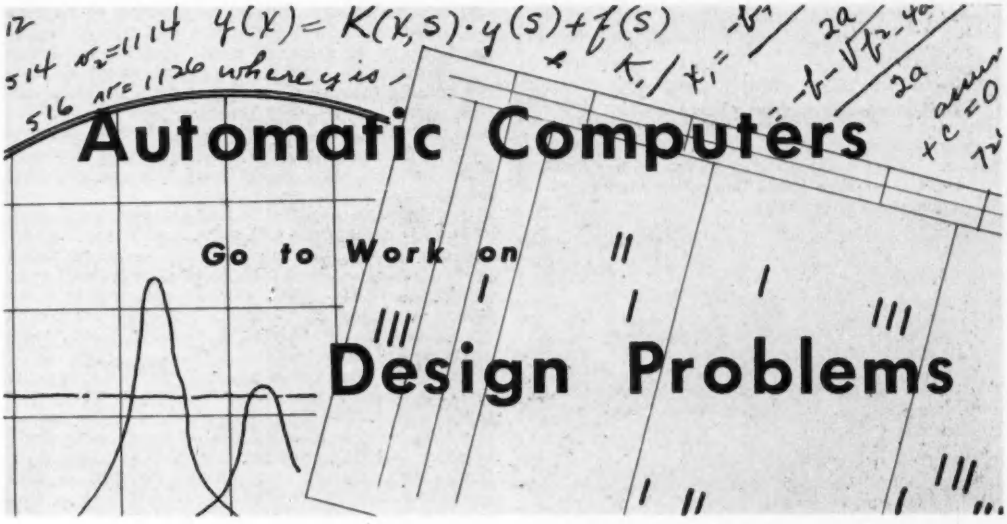


Automatic Computers Go to Work on Design Problems

MODERN computing machinery can help solve design problems as well as research problems.

Most design engineers in large engineering organizations know this because they are already using the machines. But the machines have become available so recently and their potentialities are so vast that designers generally are still too busy with the trees to see the forest. Airframe and aircraft powerplant designers have made most use of this new engineering tool so far, but there are plenty of places where ground-vehicle designers can use it too.

Computing machinery is playing an important part in the changing picture of engineering design. Years ago, an engine designer, for example, would draw plans for a new model, build it, test it, and modify it until it worked satisfactorily. Then as designers sought more power for less weight, they began to analyze mathematically such phenomena as stresses and vibrations. Engineering offices filled up with aides wielding sliderules and punching desk calculating machines. But these methods were too slow.

Some engineers faced with the complex problem of developing controls for turboprops and turbojets translated displacements, pressures, and temperatures into voltages and built electronic analogs (Fig. 1) to solve individual types of problems.

Other engineers eyed the new electronic digital computing machinery accounting departments acquired after World War II and promptly secured part-time use of it.

Engineering departments soon convinced management that they needed general-purpose analogs and their own digital computers. And they began to make greater use of machine computing services such as those offered by California Institute of Technology and International Business Machines.

The group starting out today to design a new aircraft turbine powerplant is likely to dream up a variety of compressor-burner-turbine configurations, express their performance characteristics mathematically, and calculate performance figures for each configuration over a wide range of speeds and altitudes.

Once the configuration is chosen, the computer will be used to speed calculations for design details. For example, IBM's card-programmed electronic calculator (CPC) can compute the optimum cross-sectional profile for a compressor rotor disc in about a half hour. This is a job that would take eight hours or so to do with sliderule or desk calculator. And the electronic computer is much less likely to make mistakes. Getting the answer 7½ hr sooner may not make much difference in the date the drawing is released to production. But when engineering talent is as scarce as it is now, it is important to free such personnel for work requiring trained judgment.

Electronic computers are being used in other cases where the time they save definitely is significant. One engine manufacturer estimates it would have taken 2 years elapsed time to make the vibration analysis of an experimental engine that was completed on a digital computer in 4 months.

Automatic computers deliver results of performance tests faster, too, so that designers can act on them sooner. Data from a turboprop test can be worked up in hours instead of the days it used to take. What's more, improper functioning of instrumentation is detected that much earlier. The supervisor of one turbine-engine test facility says the cost of his computing machinery is justified on the improved utilization of test facilities alone.

Equipment is on the market for recording certain types of data from test rigs directly on punched cards or on tape. This obviates need for reading of instrument indicators, hand recording of readings,

The accompanying article is based on:

The Use of High Speed Computing Machinery in Aircraft Engine Design

by Karl E. Fransson
Pratt & Whitney Aircraft

Use of Automatic Computing Equipment at Allison Division of General Motors

by J. T. Horner
Allison Division, GMC

Application of Analog Techniques to Control Design for Aircraft Engines

by W. C. Schaffer
Ram Jet Division, Wright Aeronautical Corp.

Use of Digital Computing Equipment in Propeller Design

by F. B. Stulen and J. A. DeVries
Propeller Division, Curtiss-Wright Corp.

which were presented at the SAE Annual Meeting, Detroit, Jan. 18, and

Electronic Simulation as an Aid to the Design of Vehicle Suspension Systems

by Allen Lange and John Dute
Willow Run Research Center, University of Michigan

which was presented at the SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 6.

The first four papers are available as a symposium in multilithographed form from SAE Special Publications Department at 25¢ for the group of four to SAE members and 50¢ to nonmembers. The Lange-Dute paper is also available in multilithographed form at 25¢ to members and 50¢ to nonmembers.

and key punching. Automatic plotting equipment is also available for transferring test data or calculated results on punched cards to graphical form.

In both data handling and theoretical studies, the automatic computing equipment is making possible more precise—and therefore more valuable—analysis. With the machine doing the work, it is no longer necessary to make simplifying assumptions for the sake of reducing the calculational labor.

Perhaps the greatest advances resulting from automatic calculators will come from their application to problems whose solutions are so complicated or monotonous that human computers haven't even attempted them. Both digital and analog computers are already being applied widely to such problems in aerodynamics, thermodynamics, stress analysis, and other fields.

Useful as computing machinery is for complicated, repeated calculations, it is not, of course, taking over all the computing work. For the simple, one-time calculations the design engineer is likely to encounter dozens of times every working day, it is still easier to rely on brain and sliderule or desk calculator than to prepare the problem for machine solution—and it probably always will be.

Analogs versus Digital Computers

Analogs are better for some machine computational jobs and digital computers for others. For certain types of problems, analogs are faster, but in general digital computers give more exact answers—that is, more significant figures.

Most analogs represent variables by voltages. Some analogs were built for solving one kind of problem only, like engine-control problems, and are not readily adaptable to other types of problems. Other analogs are general-purpose computers, capable of simulating nonlinear as well as linear functions. The accuracy of an analog depends on its type and the number of cells it contains.

The analog computer, unlike the digital computer, is a dynamic model of the physical system under consideration. The engineer can manipulate parameters of the analog that are "analogous" to the physical parameters. Effects are immediately displayed, which enables the engineer to keep close tabs on the physical significance of his computations.

Analogs are particularly useful for studying dynamic conditions, such as are important in turbine-engine control systems. An engineer can simulate a control system on certain special-purpose analogs by properly setting the knobs on the analog. He can study the effect of the control system on the engine under varying conditions—without ever building a single control or engine. It's a wonderful aid to design thinking, designers find.

With digital computers, the analogy is in the mathematics. Punched-card digital computers can handle any calculation that can be done by arithmetic and a book of tables. They can solve differential equations, invert matrices, multiply matrices, fit curves by the method of least squares, and evaluate definite integrals. (Tables of logarithms, trigonometric functions, and many other functions are available on punched cards.)

While digital computers are generally slower than analogs, they still operate fast. IBM's CPC, working with five-digit numbers, computes at a rate of 2174 additions or subtractions or 79 multiplications or 65 divisions per second. Fig. 2 shows the CPC.

Estimates of the number of human computers a CPC equals vary with the type of calculation considered. But for certain calculations, at least, estimates run as high as 80 experienced people working with sliderules. Most CPC units rent for only about as much as the salaries of five to seven computing aides. (Of course, the CPC does require a staff of several people to operate it.) The actual dollars-and-cents savings to a CPC user are hard to figure because the most important economies are usually the increased utility of personnel and facilities resulting from earlier availability of calculated results, and the advantage of getting the design into production and on the market earlier.

CPC units are built—to specifications worked out by the prospective user and IBM—from four standard parts: an accounting machine, a storage unit, a punching unit, and an electronic calculating unit. Since these units had been mass-produced since 1948 for accounting purposes, IBM was able to put CPC's on the market at attractive prices soon after the end of World War II. They are currently the most widely used digital computers but there are 10 or 20 other digital computers on the market and more being developed.

There are four steps between a problem and the computation of its solution on a punched-card computer:

1. Stating the problem in the form of a mathematical equation.
2. "Programming" the solution—that is, figuring out the steps the machine shall take in performing the solution. (This step corresponds to formulation of a worksheet for sliderule computation.)
3. Wiring the problem on the control panel of the machine. (Some companies maintain small libraries of control panels already wired for certain computations performed frequently.)
4. Punching data and instructions onto the cards and feeding the cards into the machine.

Programming and wiring are usually checked by performing a hand calculation for one set of conditions.

In some companies groups of computer specialists take care of all but the first step, which is, of course, the designer's responsibility. Men specially

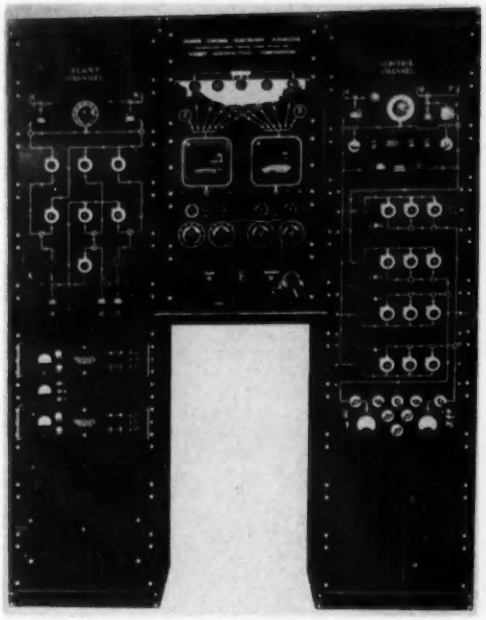


Fig. 1—Wright Aeronautical's original analog built to represent a general turboprop engine with a variety of control systems. A particular engine and a specific control are established by proper settings of the various dials and arrangement of the interconnecting leads

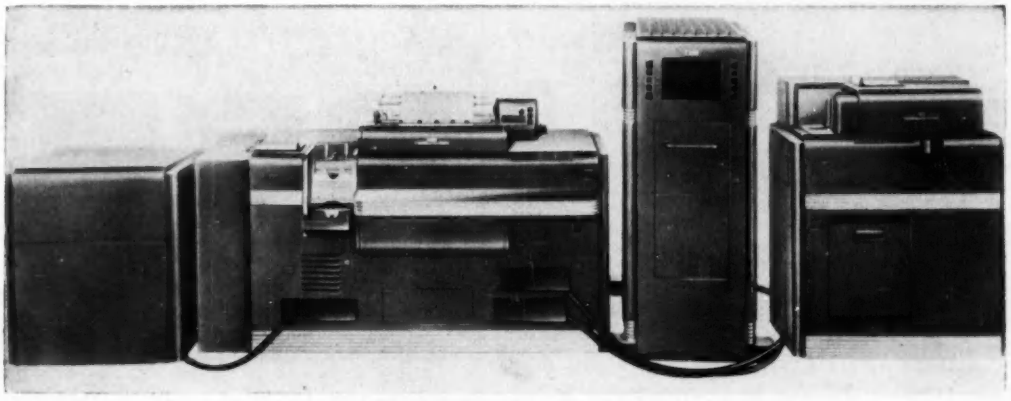


Fig. 2—The IBM card-programmed electronic calculator, Model II

TWO digital computers helped television commentators digest Election Day figures as they poured in.

NBC used Monroe Calculating Machine Co.'s Monrobot, a computer housed entirely in one desk-like unit containing less than 1000 tubes and weighing only 1500 lb. Monrobots will soon go on sale for $50,000-$70,000, depending on storage capacity of their magnetic memory.

CBS viewers saw Remington Rand's larger Univac. This 5500-tube computer uses magnetic tape instead of punched cards for programming and has a mercury-tube memory. Government agencies got the first installations two years ago. Now the Univac is on the market at $600,000 and up, according to storage capacity.

trained in use of computing machinery, as well as engineering or mathematics, accomplish the programming. Skilled wirers set up the control panels, and key-punch operators—usually young women—prepare and feed the cards.

Allison Division of General Motors is one of the organizations which maintain a machine computing group. Allison at first had engineers do their own programming, but found that unsatisfactory. Computing specialists, Allison management feels, program machines more efficiently and don't waste time on divergent solutions, which, of course, the machine can't handle. The computing group consists of math and physics majors and graduate engineers. The engineers are drawn from other groups and eventually return to them. This gives them perspective on automatic computers as a major tool of engineering.

Other engineering organizations have their engineers program their own problems. It takes several months to train a man thoroughly in programming, but the fundamentals can be picked up in an hour.

Allison, like Wright Aeronautical and Pratt and Whitney Aircraft, is using automatic computing machinery in design and performance calculations as well as in many phases of research. Chrysler uses digital computing equipment for determining intersections of already designed hydraulic drive turbines and shrouds to put on production drawings. Chrysler uses their equipment also for designing gears and studying vibrating systems. Other automobile manufacturers are working similar types of problems on computing equipment in their plants and at Wayne University, which takes on some jobs in connection with courses offered in the field of computing equipment. In fact, Detroit has an Industrial Mathematics Society devoted largely to use of automatic computing equipment.

Several airframe manufacturers are not only using digital computing equipment but also building and offering it for sale. And many companies are turning to computing machinery for production control.

Details of some of the applications of computing machinery to engineering design problems follow.

Wright's Analogs Simulate Engines and Controls

W. C. Schaffer Wright Aeronautical Corp.

WRIGHT Aeronautical has been developing analog techniques for over five years and has used analogs extensively for the solution of control problems for jet engines.

The principal equipment utilized has been of the high-speed electronic type developed by G. A. Philbrick of Boston, Mass. However, mechanical and pneumatic analogs have also been used.

Initially, a fixed array of analog equipment was believed to be most desirable for the investigation of turboprop control design. Such an analog is illustrated in Fig. 1, the original analog to represent a general turboprop engine with a variety of control systems. A particular engine and a specific control are established by proper settings of the various dials and arrangement of the interconnecting leads. The configuration is such that settings, both dynamic and static, are provided for the related influences of five variables affecting engine operation. In the control channel four controllers are provided that can be interconnected in any desired manner to the five engine variables. An

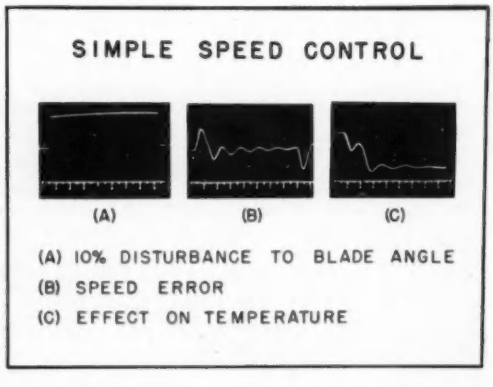


Fig. 3—Typical results from Wright Aeronautical's original engine-controls analog. Traces are solution to a simple speed-control problem

arrangement is also provided to represent alternate means of propeller pitch change and fuel regulation.

Typical results from this analog are displayed in Fig. 3 which shows the time solution to a simple speed-control calculation. These curves would require approximately 4 hr to compute manually. More important, the determination of optimum values might require weeks of manual computation, but with this analog the problem can be set up and the optimum solution obtained in less than 1 hr. Consequently, such problems can be thoroughly investigated and checked.

In the Philbrick analog, voltages are used to represent the variables and are measured on oscilloscopes as plots against time or each other. The computing voltages are interconnected so as to vary in magnitude and phase in the same manner as their physical counterparts. The power input required is 110-v, 60-c current. A computing period is 1/240 sec, obtained by using a square-wave disturbance derived as one-fourth of the 60-c current. This computing speed is truly remarkable: Hours of computation are reduced to less than 0.005 sec and are repeated at a rate of 240 cps. Thus, once a computing circuit is set up, answers are available, and the effects on the solution of desired parameter variations are immediately apparent.

From the experience gained with the first Wright Aero analog, the second analog shown in Fig. 4 was procured. This unit is quite similar to the first but contains improved circuits and provides greater flexibility. Although these two machines were specifically designed for turboprop control investigations, they have been successfully used for the study of other problems. However, such applications are limited by the fixed array of components since the plant channel only provides a fixed relationship, with adjustable coefficients and time constants, for the five variables.

Greater flexibility is provided by utilization of analog components such that each unit provides one mathematical relationship between input and output voltages. Thus, an adder unit combines four voltages to produce an output voltage which is the algebraic sum of the inputs, and a coefficient unit provides an output voltage which is the product of the input and a factor determined by the dial setting. More involved units include those which multiply two varying voltages, integrate, differentiate, and square. In fact, one unit, called a "function fitter," can be adjusted to approximate any relationship between two variables. Trigonometric relationships can be represented as well as Fourier series. Special cases of the functions of two independent variables can also be handled.

Hysteresis, dead zone, and bounding are characteristics of physical systems that have plagued the mathematical investigator and which have sometimes been neglected in otherwise elaborate computations. However, such components for the Philbrick analog are available and are used extensively by Wright Aeronautical in the investigation of control devices. Engineers concerned with the development of physical devices will appreciate the convenience afforded by these non-linear computing components.

Two typical Philbrick analog components are

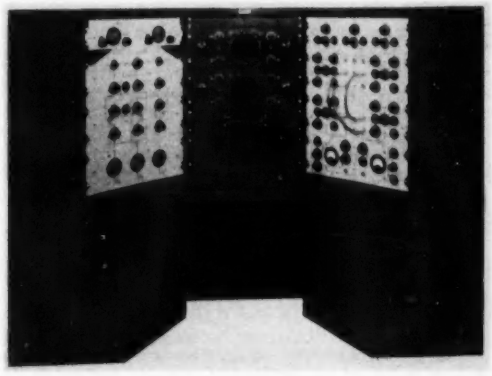


Fig. 4—Second analog acquired by Wright Aeronautical for engine-controls studies

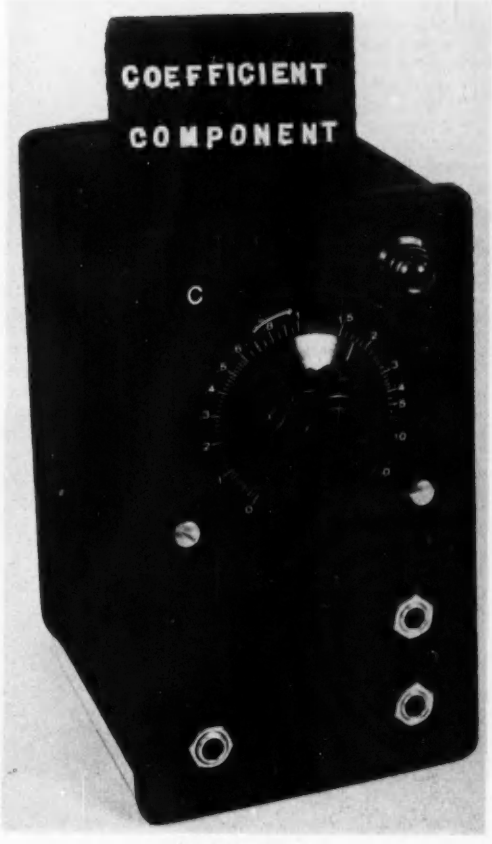


Fig. 5—Analog units

illustrated in Figs. 5 and 6. The coefficient box's input signal is connected to the left-hand jack and a selection of positive or negative output is provided by the two jacks to the right. The dial setting provides the coefficient value. In this unit the output is the product of the input and the coefficient. All power connections are made in the rear. In the more elaborate function fitter, once again the input is the left-hand jack with a choice of positive or negative output, and the power connection is in the rear. The upper dials set incremental slope with the lower dials determining the length of increment. By these means a curve is fitted to pass through ten selected points in much the same manner as a French curve is used in curve plotting.

In cooperation with the United States Air Force, Wright Aeronautical has procured an assortment of such components, primarily to investigate the control of ramjets. A typical array is shown in Fig. 7. In this arrangement, missile, engine, and control characteristics are represented for determination of desirable control configurations. The effects of both variations in parameters and in types of disturbances are readily determined and visualized. Aside from control studies, similar arrangements are used in trajectory studies to determine effects of launch angle, rate of climb, and other variations.

Fig. 6—Analog unit

The contributions of the analog to control development at Wright Aeronautical have been many. As a research tool for the investigation of control theory and application, it reigns supreme. Individual control mechanisms and circuits can be readily evaluated. Both quantitative and qualitative design information can be obtained. Specifically, control systems designed from analog results have successfully operated reciprocating, turboprop, and ramjet engines. The particular items determined from the analog are control arrangements, relationships of time constants, required control sensitivities and gains, tolerances of the control system to engine variations, stability of the controlled engine, and the response of the system to various disturbances.

Secondly, the analog has been an excellent means for training control engineers. The man learns by doing, and the results of changes are immediately apparent. There is no time delay for revision of parts: A twist of a dial, the flip of a switch, or the change of a lead and the system is revised. Integral control, in all its ramifications, is quite difficult for the uninitiated to comprehend; however, a brief review with analog equipment can quickly dispel the mystery. We have established a standard practice of training engineers concerned with control development to become familiar with operation of the analog. The advantages of the program are twofold. First, the engineer has a better understanding of controls and the overall program. Secondly, he learns to think in terms of the analog and will feel free to utilize the advantages of analog techniques.

Another contribution of the analog has been realized in simplification of control circuits. In some cases as much as a 50% reduction in complication has been achieved as a direct result of analog investigations. An inherent fundamental of analog technique is the reduction of any problem to essen-

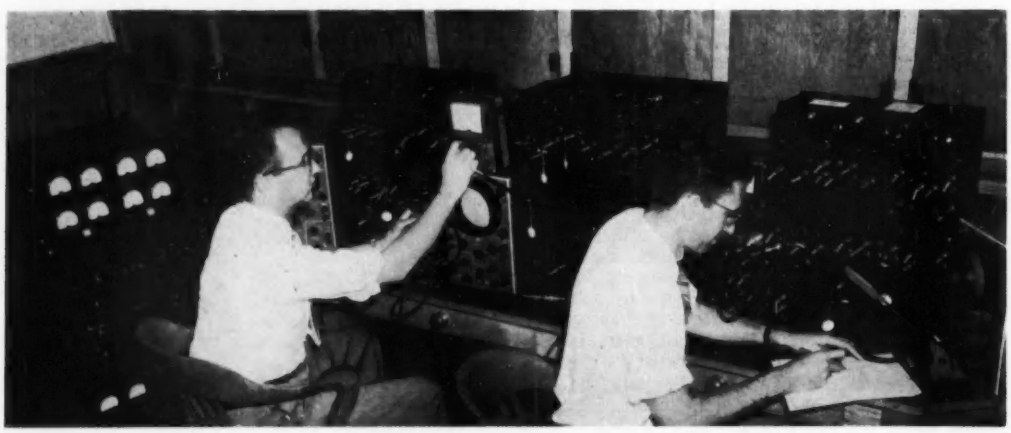


Fig. 7—Typical array of analog components

tials. Thus it is the very nature of analogs that leads to simplification.

The determination of causes for apparent control malfunctioning is still another fertile field for analog investigation. Here the great banes of control development—namely: lag, dead space, and hysteresis—can by no other means be so readily evaluated. Furthermore, when an engine is being tested, and it is very expensive to test engines, modifications and adjustments of the control system are not easily accomplished. There is a definite limit to how many trials may be attempted, but there is no such limitation with the analog; and, what is more, it is cheaper in both time and money.

U. of Michigan Studies Vehicle Suspensions with Analog

Allen Lange* **and John Dute** Willow Run Research Center, University of Michigan

AT THE Willow Run Research Center we have found that analog computers can be of considerable utility in analyzing, among other types of problems, these four varieties of vehicle-suspension problems:

1. Chassis motion of vehicles with multi-wheel suspensions.
2. Complex chassis and axle motions with three or more degrees of freedom.
3. Problems involving the chassis as an elastic, rather than a rigid, body.
4. Non-linear problems.

Our electronic simulator consists of a group of high-gain d-c amplifiers so connected that the differential equations defining the resulting circuits are mathematically equivalent to the differential equations describing the motion of the vehicle. The ability of the d-c amplifier to perform certain mathematical operations depends principally on its high-gain and the fact that the output signal is fed back to the input.

In Fig. 8 the differential equation describing the motion of the mass can be shown to be the mathematical equivalent of that of the circuit. The first amplifier is used as a sign-changing device. The second amplifier sums all the forces acting on the mass. The third and fourth amplifiers integrate the sum of all the forces acting on the mass (that is, the acceleration of the mass) twice to obtain the displacement of the mass. (This problem is usually solved with three rather than four amplifiers; but showing four amplifiers illustrates more clearly the functions of sign-changing, summing, and integrating.)

The steps in making a theoretical study of the motion of, for example, a passenger car with individual front-wheel suspension and Hotchkiss drive are:

1. Derive the set of 18 equations describing the motions of the vehicle.
2. Eliminate the motions and terms in the equations that have no engineering significance.
3. Divide the remaining equations into symmetric and asymmetric motions. Usually these two groups of equations are considered independent, with no coupling between them.
4. Simplify the two groups of equations by considering frequency limitations.

These steps in the theoretical study of the motions of a vehicle may be performed by hand calculations in a straight-forward but time-consuming manner. However, by using a simulator, quantitative as well as qualitative information concerning the various modes of motion can be obtained more easily and quickly. Moreover, it prepares the engineer to use the simulator to analyze a specific vehicle.

In the course of an experimental testing program, it is not unusual that difficulties arise as to the meaning or validity of the results of the tests. When the simulator is used to solve the differential equations describing the motion which is being measured experimentally, the simulator may be thought of as an electronic model of the vehicle. As a consequence of this concept, the simulator can

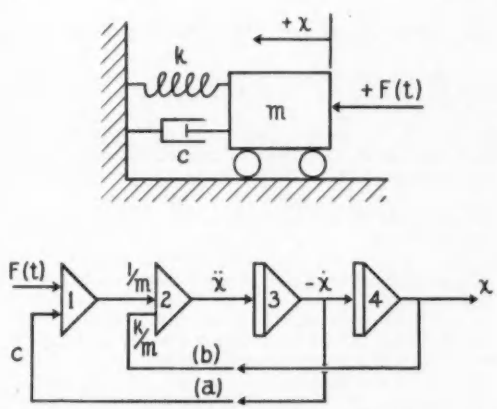


Fig. 8—Schematic diagram of mass-spring-damper problem and its electronic analog

* Now with Instrumentation Laboratory, Massachusetts Institute of Technology.

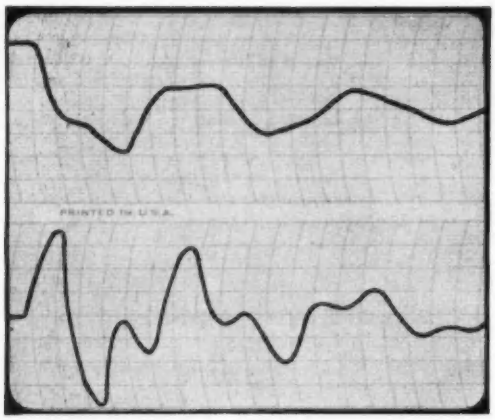


Fig. 9—Response of two spring-coupled masses to a step input

"pace" the vehicle being tested and the results of the computer solution can be compared with the experimental results.

The computer solution, which is usually presented as a graphic display (see Fig. 9) of some variable voltages versus time, is analogous to the motion of the vehicle. The simulation, therefore, has several distinct advantages over other methods. These are: (1) by relating experimental data to that obtained from the simulator, spurious information may be identified; (2) experimental data which is valid but not understood will become acceptable to the engineer if it also occurs in the solution of the computer; (3) by the process of forming the analogy, the engineer gains a better understanding of the original problem; (4) the simulator, thus used, can actually supplement and, to a certain extent, replace the experimental program. The latter is due to the fact that the simulator becomes a model of the vehicle, available to the engineer regardless of weather. It provides test results that are free of inaccuracies introduced by measurements of vehicle speed, course condition, and such variables. By adjusting circuit elements in the computer, the test engineer is able to calculate the effect of assigning various values to parameters of a suspension system. These circuit elements are analogous to the dynamic elements in the suspension system.

When this technique of analysis has been mastered, the next step, synthesis, follows naturally. Given the problem of designing a vehicle whose approximate size is known and given specifications limiting the various motions of the vehicle to some range considered to be optimum, values may be assigned to the various springs, shock absorbers, and linkages.

The engineer need only manipulate a few knobs until the solution falls within the desired range. Admittedly, this requires a cut-and-try method of solution. However, these solutions can be accomplished so rapidly that the drudgery usually implied by a cut-and-try solution is completely eliminated, and due to the rapidity of the operation, an optimum, or near-optimum solution is more readily obtainable.

Allison Makes Wide Use of Digital Computer

J. T. Horner Allison Division, GMC

ALLISON, like some other users of the IBM card-programmed electronic calculator, uses it in four phases of engineering work:

1. Calculation of numerical data for generalized design studies.

2. Detailed design of the component parts for an engine.

3. Analysis of the performance characteristics of both the components and the whole engine after the design is complete.

4. Research studies, such as boundary-layer studies, two-dimensional cascade flow studies, and flutter analysis. Many of the problems now attacked were bypassed formerly because the calculations were too tedious for human calculation.

To man the CPC, there are a machine operation staff including a machine supervisor and three machine operators and a key punch operator, and an engineering staff including an engineer with two assistant engineers.

The engineering staff schedules all calculations performed on the CPC. The bulk of the problems handled are fairly routine mechanical design problems and problems in thermodynamic analysis. During the time a problem or set of problems is running, other problems of future interest are examined, coded, and checked. Tables and other pertinent data are also prepared. The engineering staff also plans the general operating procedures

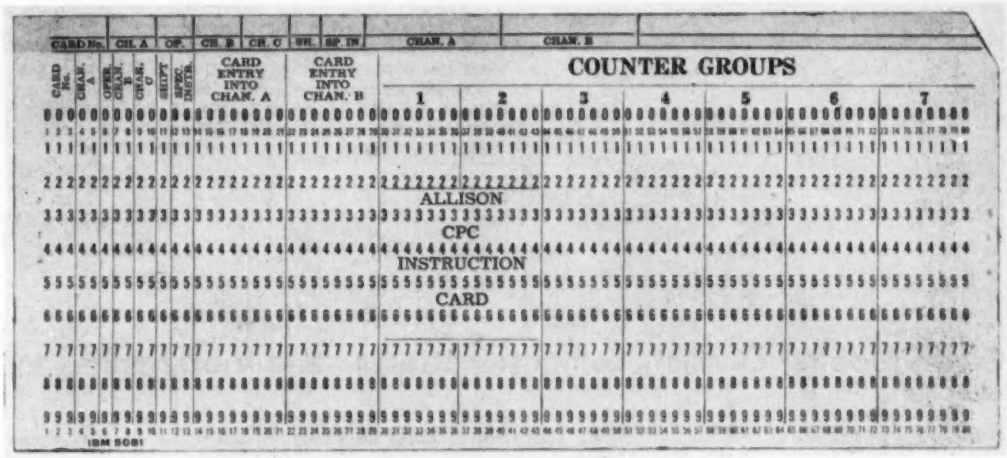


Fig. 10—Standard IBM card for card-programmed calculators

for machine calculations and initiates such changes in the machine set-up as will lead to consistent coding or programming procedures, easier card handling, and increased speed of operation.

The machine operation staff handles all changes in plug-board wiring and other changes in the machine set-up, devises card-handling procedures for the most economical running of a problem, and schedules the given problems in such a manner that there is an uninterrupted flow of cards through the CPC. This "uninterrupted flow of cards" includes running during the lunch periods, which are staggered to permit continuous operation. Checking operations, machine break-down, card handling in certain problems, and lack of foresight in planning are factors which disrupt this ideal mode of operation.

The CPC has enormous flexibility due to the large number of plug connections which can be made in each of two plug boards which schedule machine operations. One plug board schedules calculations in the electronic computer; the other handles the read-in and read-out and the storage of numbers. For general-purpose operations these plug boards are wired in such a manner as to perform the majority of the calculations occurring in engineering problems. Such a set-up is slower but much more flexible than one wired only to handle a particular problem.

At Allison, the arithmetical electronic computer has been wired as a general-purpose calculator to add, subtract, multiply, divide, form a square root, find the natural logarithmic of a number, raise the natural logarithmic base, e, to a power, calculate the trigonometric functions and the anti-trigonometric functions, and calculate the hyperbolic functions in any sequence. All of these calculations take place at electronic speeds, the average running speed being 100 cards a minute. Also available is the ability to perform a table look-up in order to find values from empirical or calculated data. This can also occur in any desired location within a sequential operation.

The table look-up is a comparatively slow operation since 10 to 30 cards may be required for a table. However, other calculations can be scheduled to take place while the table is being searched; in addition, two different functions of the same argument can be found at the same time. Thus proper planning can decrease the running time for a problem requiring many tables to be searched. The coding of problems has been planned so that problems may be programmed for machine calculations in a fairly routine manner once the preliminary problem planning and sequence of operations has been established. Coding the problem for machine calculations at this stage involves the same amount of planning required to develop a worksheet for a computing staff. Due to storage limitations or other considerations, problems must often be solved in several distinct operations. Problem planning is simplified here by the use of the standard card form shown in Fig. 10. Notice that there are nine number fields, each of which holds a seven-or eight-digit number. All information in a problem is read from the same standard card and punched into another identical card. Control coding may be emitted and punched together with the numerical results; thus the punched results are ready to use immediately in the next calculation.

The same general purpose set-up is used to solve the majority of problems handled. Certain problems can be solved economically only by this set-up which has available the ordinary operations and functions used in engineering calculations; other problems are scheduled for only a few hours running so that any special procedures or new plug-board wiring to shorten running time would be uneconomical. Occasionally, however, for a long problem, a special set-up is wired. The advantages and disadvantages of such procedures can be illustrated by the following simple example where the

real roots are found for the quadratic equation:

$$ax^2 + bx + c = 0$$

Here:

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

$$x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$$

The general-purpose set-up can be programmed for this calculation and checked in 20 min. Then, after cards are punched containing *a*, *b*, and *c*, 100 equations may be solved in 10 min. A special purpose set-up would solve the 100 equations in 1 min but a day and a half or longer of planning, wiring, and checking would be needed before the problem could be started.

C-W Propeller Division Computes Stresses and Vibration

F. B. Stulen and J. A. DeVries Propeller Division, Curtiss-Wright Corp.

THE Propeller Division of the Curtiss-Wright Corp. solves a variety of engineering design problems on its IBM card-programmed electronic calculator (Figs. 11-13). A typical application is the computation of propeller blade stresses and vibration characteristics.

The basic mathematical equations to be solved in these stress and vibration problems are two simultaneous fourth-order differential equations. These differential equations have variable coefficients and take into account the blade twist, the variation in flexibilities, and the mass distribution of propeller blades along the blade radius. In addition to this, the boundary conditions including the flexibility of the retention of the blade in the hub must be properly introduced. The ratio of the blade section stiffnesses from one end of the blade to the other is approximately ten thousand to one in some of the modern propellers for turbine engines.

Precise methods of analyzing the vibrations of a propeller blade, including the effect of blade twist and other complicating factors, were previously known. But there was little effort to develop and employ them until approximately five years ago. The reason for this was that the aerodynamically-excited vibrations of a propeller, which are one of the more important types, were not very significant until recent years when the continually increasing wing loadings and speed ranges of new airplane designs subjected the blades to greater vibratory excitations. Combined with this effect was the design trend of reductions in blade section thicknesses

Fig. 11—Curtiss-Wright Propeller Division's engineering IBM equipment installation. Woman is seated at the reproducing punch. Next machine is an electronic sorter. The other units are part of the CPC

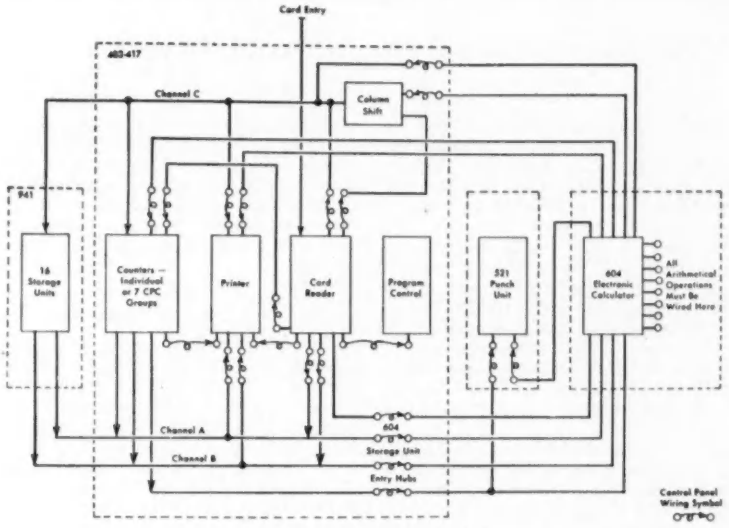


Fig. 12—Block diagram of the CPC

in order to improve the aerodynamic efficiency of the propeller at the increased forward velocities. These requirements necessitated greater accuracy in the structural analyses of new designs than was formerly required. Hence a more precise mathematical formulation of these problems became mandatory.

Transformation of the basic differential equations, representing the blade structural problems in general, into a linear integral equation is an effective means of solution since a linear integral equation can be readily transformed into an equivalent matrix equation. The matrix representation of these equations in the inhomogeneous form is:

$$y(x) = K(x,s) \cdot y(s) + f(x)$$

where y represents the unknown moment or deflection components which are to be calculated along the span of the blade (as a vector matrix), $K(x,s)$ represents the square matrix, and f represents the inhomogeneous part of the matrix equation. When the equations have been written in the matrix form the problem resolves to one of calculating the solution of a large number of simultaneous equations which have the form:

$$\begin{aligned}
a_{11}y_1 + a_{12}y_2 + a_{13}y_3 + \ldots + a_{1n}y_n &= b_1 \\
a_{21}y_1 + a_{22}y_2 + a_{23}y_3 + \ldots + a_{2n}y_n &= b_2 \\
a_{31}y_1 + a_{32}y_2 + a_{33}y_3 + \ldots + a_{3n}y_n &= b_3 \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
a_{n1}y_1 + a_{n2}y_2 + a_{n3}y_3 + \ldots + a_{nn}y_n &= b_n
\end{aligned}$$

where the a_{ij} terms represent the coefficients of the unknown variables in the simultaneous equations, y_j represents the unknown deflection or moment components, and b_j represents the inhomogeneous parts of the equations.

In the case of the structural problems of propeller blades the number of simultaneous linear equations varies from 20 to 40, depending on the size of the propeller being analyzed.

Various methods have been established for the solution of linear differential equations—each of which has its own merits. But of these, matrix representation is one of the most suitable for IBM computing equipment.

Solution of the propeller equations by any of the various available methods of solution is impractical for hand calculation. This is due to the very large number of numerical operations and high degree of accuracy that must be maintained in the calculations. It is estimated that to calculate the solution of a large number of simultaneous equations such as these by hand calculations, with only the assistance of conventional desk calculators, would require between one and three man-months, taking into account the probability of errors occurring. This length of time is prohibitive for numerous reasons, probably the most important of which is the need for quicker solutions in order to complete the engineering design in a reasonable length of time.

Our best estimate is that for this particular problem of propeller stress and vibration calculations, the CPC is the equivalent of about 80 average computers working with desk calculators. The CPC costs about as much in rental as salaries for five to seven computers and requires a staff of six people to program, operate, and maintain it.

Turn page for more

Pratt & Whitney Compares Digital Computer and Analog

Karl E. Fransson Pratt & Whitney Aircraft Division

ENGINE designers today are interested in the vibration characteristics of engine rotors and structures when operating as a unit. For an aircraft design, such a rotor will weigh roughly the same as the frame which surrounds it, and will be supported at several points through bearings. Vibration characteristics of such an engine may be examined by constructing scaled models. Where the configuration is simple, particularly where few bearing points are involved, this is the way to do the job. Where the engine design is complex, this approach is too expensive. Use of experimental engines is impractical principally because the number of test configurations is seriously limited. In this type of environment, high-speed computation methods appear attractive.

Vibration analysis of an experimental engine was conducted in our analytical group by setting up a mesh of differential equations describing the behavior, over the complete range of engine operating speeds, of the essential component parts. Solution of this mesh of equations was completed on IBM equipment, but presented several unusual problems. Because of the high order of precision desired, calculations were carried to several significant figures —which taxed the digital capacity of the computing equipment. Ingenious means were devised by our computing group, working with the New York staff of IBM, permitting us to shift decimal places.

Analytical and Test Results Correlated

The answer obtained was in the form of a frame and rotor deflection curve for each of the important vibration frequencies. These curves have permitted us to study the relative motions of the frame and rotor at shaft bearings and seals. Recommendations resulting from this study are changes in bearing configuration and frame stiffness, permitting engine weight savings. More valuable than these specific design proposals is the knowledge acquired from checking our calculations with engine test data since it has become available from test stand operation.

Elapsed time for this vibration analysis was four months. A breakdown of this figure shows that one month was consumed by preliminary work involving a study of probable orders of precision. One and one-half months were spent in assembling engine mass and stiffness constants. One month was devoted to set-up of differential equations. Only three weeks of machine time were required to obtain the final answers, including plotting of curves. We have estimated that this problem would have required two years of elapsed time, had all computations been made only with the aid of slide rules and desk computing machines.

But even four months is a long time to wait for any answer when a new engine is in the layout stage. An appraisal of computing time on the forementioned problem showed us that three-quarters of the elapsed time was devoted to setting down the problem in terms that the calculating machinery could understand. An electric analog computer would appear to eliminate some engineering preparation time, since the mode of analog operation would be similar to engine operation, and require only a statement as to how the engine is constructed.

CIT Analog Used

Our problem was consequently presented to Dr. G. D. McCann of California Institute of Technology for solution on equipment available at the Institute. Although we had entertained doubts as to the feasibility of working with a computing group separated from us by such a long distance, it worked out very well. Since the problem was in process on our own IBM equipment, little effort was required to submit stiffness and mass constants to Dr. McCann. However, we included shear deflection effects and damping effects which appeared too formidable to handle in the first calculation performed on the digital equipment.

The analog set-up employed 81 units, for which was obtained an accuracy in frequency spectrum comparable to that for the digital calculation. Electrical losses are small in the 100 cps to 1000 cps frequency range where the calculations were performed. Largest errors are those inherent in the discrete or cell-type solution. Set-up time was approximately three days and calculation time "one Saturday afternoon." Answers compared with engine test data and digital computations checked closely with both.

For problems of this type, analog computers appear very attractive, but first cost is high for enough equipment to obtain good answers. Several of our simpler problems or problems in which we can accept less precision could be solved with half as much equipment as was required on our critical vibration problem. The correct approach to the question of assembling an analog computer would appear to involve justifying acquisition first of enough cells to solve the simpler problems that occur frequently—then to accumulate cells for the more complex problems.

Too Soon to Choose

It is impossible to predict at this time whether the advantages of short set-up and calculation time for the analog will outweigh the advantage of inherently better accuracy for the digital equipment.

Investigation of engine vibration characteristics is, of course, only one of the uses to which Pratt & Whitney Aircraft is putting its digital and analog computers. They are being used to speed solution of many other design problems as well as to reduce raw test data to forms suitable for analysis and to solve analytical research problems.

a realistic look at titanium

R. W. Parcel, Rem-Cru Titanium, Inc.

Based on paper, "The New Metal, Titanium: Its Application and Processing," presented at SAE Summer Meeting, Atlantic City, June 2, 1952.

TITANIUM is an attractive addition to the list of structural metals because:

- It has a good strength weight ratio, which it maintains up to about 1000 F, and its endurance limit/ultimate strength ratio is unexcelled.
- Its yield strength is as high as that of the better grades of steel.
- It is ductile enough for many forming operations.
- Salt water, wet chlorine, organic acids, and strong alkalies have little or no effect on it.
- It successfully withstands standard flame impingement tests.

But titanium, just as other metals, has its limitations and drawbacks. Here are some:

- Titanium is not suitable for bearings or other friction-loading applications because of its tendency to gall.
- Molten titanium combines readily with carbon, oxygen, and nitrogen, leading to high production costs.
- Commercially pure titanium machines about like stainless steel; but its alloys are, generally speaking, less machinable.
- Titanium must be completely protected from air during welding.
- The cost of titanium is not likely to approach that of the common metals for a long time.

Properties of Titanium and Its Alloys

The mechanical properties of two commercially pure grades of titanium, RC-55 and RC-70, and two alloys, RC-130-A and RC-130-B, are listed in Table 1. Fig. 1 shows that the titanium alloys are superior to most other structural materials on a strength-weight basis, and the pure titanium, RC-70, excels 301 stainless steel up to 800 F.

Titanium lies between iron and aluminum in density, exceeds them in corrosion and flame resistance, and compares favorably in yield strength with steel, as shown in Fig. 2. The ratio of endurance limit to ultimate strength of titanium and its alloys is greater than that of any other structural metal.

Machinability of the commercially pure metal is close to that of stainless steel, but the titanium alloys are more difficult to machine. Titanium galls under friction loading, such as in bearings. At room temperatures, it will creep at loads below its yield strength, but above 300 F its creep strength is higher than the yield strength. Titanium generally has no advantage over stainless steel above 800–1000 F. The exception to the temperature limitation is in the use of titanium as a flame barrier—Fig. 3 gives visible proof of this.

Titanium's extreme sensitivity to oxygen, nitrogen, and carbon is such that a few tenths of a percent of any one of them embrittles the metal. And here's where the high cost of production lies. Molten titanium eats up the oxygen in refractories and is seriously contaminated by carbon crucibles. The only commercial remedy so far has been the cold-mold furnace, in which a layer of solid titanium is always between the melt and the wall. The space over the melt is exhausted of air as completely as possible, and the melting is carried out under a vacuum or an inert-gas atmosphere.

Titanium Can Safely Go to Sea

Three years of marine tests at Kure Beach, courtesy of International Nickel Co., showed titanium to be utterly unaffected by continuous or inter-

mittent salt-water exposure. See Fig. 4. Titanium was surpassed only by 16 Cr-6 Ni steel in salt-water cavitation tests made by the Navy. Titanium is the only high-strength metal whose endurance limit in salt water approaches the limit in air.

Commercially pure titanium is not appreciably affected by:

1. Wet chlorine gas
2. Boiling chlorides
3. Nitric acid—up to 98% at room temperature
4. Sulfur and sulfur compounds
5. Strong alkalies
6. Organic acids
7. Chlorinated solvents

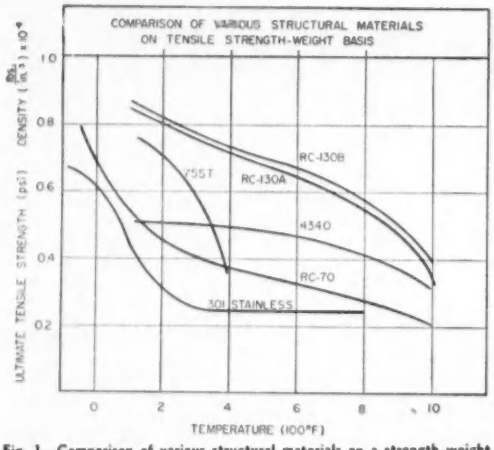


Fig. 1—Comparison of various structural materials on a strength-weight basis

On the other hand, there is appreciable attack by:

1. Dry chlorine gas
2. Hydrochloric acid—5% and greater at room temperature; 1% and greater at boiling
3. Hydrofluoric acid in any concentration
4. Sulfuric acid—5% and greater at room temperature, 1% and greater at 80 C

Fabrication Hints

Titanium and its alloys forge nicely at 1700 to 1800 F and roll well at 1400 to 1600 F, the upper limits being set by oxidation and the lower ones by ductility. The pure metal grades cold work without damage, with moderate strain hardening. Alloys can be cold worked about 25% between anneals, if sufficient force is available.

Welding, sheet forming, and machining require care to produce good results:

1. Welding must be done under complete protection from air, using inert arcs or one of the self-protecting techniques such as spot or seam welds. These welds have somewhat lower ductility than the parent metal. Pure titanium joins with itself quite well, but no other metal has been satisfactorily joined with titanium.

2. Most of the conventional techniques for sheet forming apply to titanium sheet and all but the most severe of these to alloy sheet. Some airframe plants heat the sheet to 400 to 700 F during forming, thereby reducing, momentarily, strength and springback. Increased ductility and uniform elongation at these temperatures permit stretching, spinning, dimpling, drawing, joggling, hydropress forming, and brake forming. The more difficult of

Table 1—Room-Temperature Mechanical Properties of Titanium and Titanium Alloys

	RC-55 Sheet	RC-55 Rolled Bar	RC-70 Sheet	RC-70 Rolled Bar	RC-130-A Sheet	RC-130-B Rolled Bar
Ultimate Tensile Strength						
Typical, 1000 psi	75	75	90	90	130	150
Nominal Minimum, 1000 psi	65	65	80	80	120	140
Compressive Yield Strength (0.2% Offset), 1000 psi	63	...	78	82	...	140
Tensile Yield Strength (0.2% Offset)						
Typical Longitudinal, 1000 psi	65	65	80	80	115	140
Typical Transverse, 1000 psi	65		80		120	140
Nominal Minimum, 1000 psi	55	55	70	70	110	130
Tensile Elongation (2-in. gage)						
Typical, %	25	25	20	20	15	18
Nominal Minimum, %	20	20	15	15	10	10
Reduction in Area						
Typical, %	...	50	...	40	...	40
Proportional Limit						
Typical, %	50	...	65	70	95	105
Bend Ductility						
Typical Bend Radius (up to 0.1 thick)	1.5T		2.0T		2.0T	
Nominal Maximum	2.0T		3.0T		3.0T	

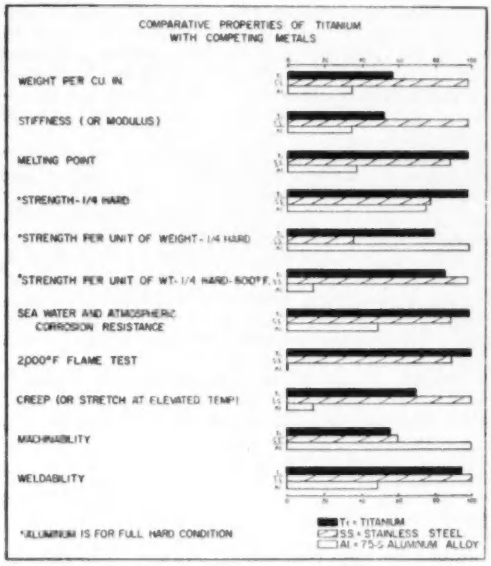

COMPARATIVE PROPERTIES OF TITANIUM WITH COMPETING METALS
WEIGHT PER CU. IN.
STIFFNESS (OR MODULUS)
MELTING POINT
*STRENGTH-1/4 HARD
*STRENGTH PER UNIT OF WEIGHT-1/4 HARD
*STRENGTH PER UNIT OF WT-1/4 HARD-600°F.
SEA WATER AND ATMOSPHERIC CORROSION RESISTANCE
2000°F FLAME TEST
CREEP (OR STRETCH AT ELEVATED TEMP.)
MACHINABILITY
WELDABILITY
*ALUMINUM IS FOR FULL HARD CONDITION
T = TITANIUM
SS = STAINLESS STEEL
AL = 75-S ALUMINUM ALLOY

Fig. 2—Properties of titanium, stainless steel, and 75S aluminum

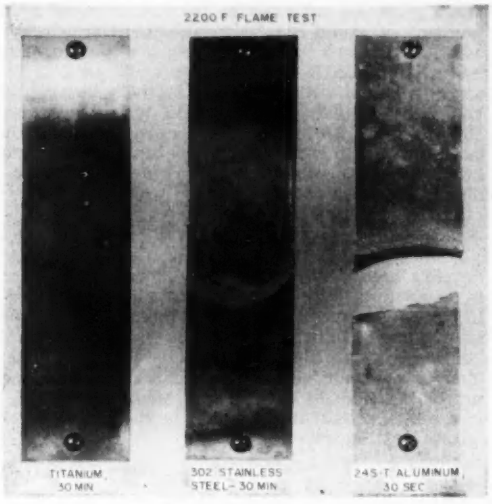


Fig. 3—Titanium is unaffected by 30-min exposure to flame at 2200 F

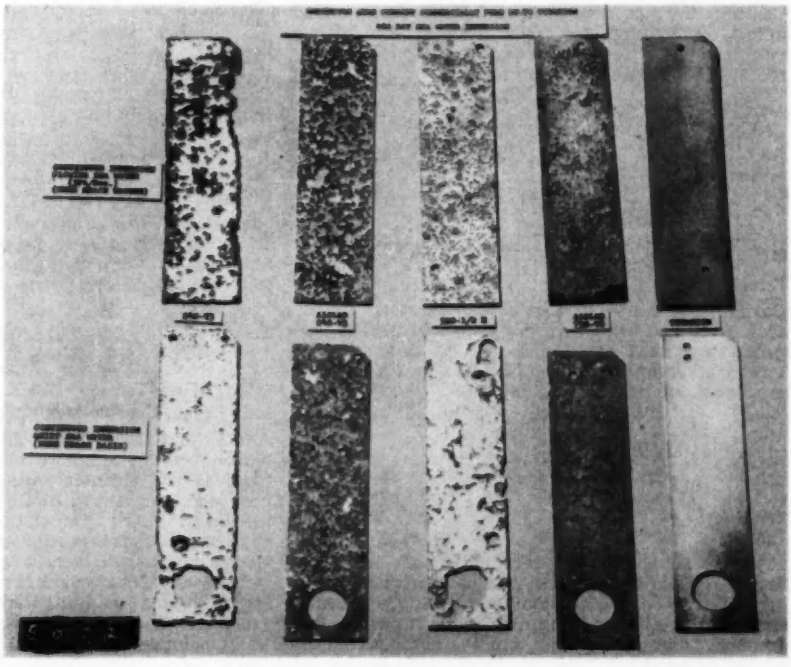


Fig. 4—Results of salt-water exposure of titanium and several aluminum alloys. Upper samples faced continuous immersion in sea water flowing at rate of 3 fps. Lower samples faced continuous immersion in quiet sea water

these processes may not be feasible at room temperature or would require a subsequent anneal.

3. Machining of titanium requires slow speeds, heavy cuts, positive pressures (no tool drag or interrupted cuts), and very sharp tools because of titanium's tendency to gall and its low thermal conductivity. Scale removal is more important for titanium than for most other metals—the extreme hardness of the oxides and nitrides will quickly dull the hardest tools.

Many Peace-Time Uses Seem Possible

Sizable marine applications of titanium should develop because in salt-water exposure, titanium is equalled only by platinum and Hastelloy C; and in salt-water fatigue, no other material approaches its endurance limit. Titanium's resistance to chlorine and other bleaches foretells its use in the chemical, textile, and paper industries. Surgical use of titanium in bone screws, plates, and braces has been successful—not only is the metal inert, but flesh will grow on it.

Present applications have been limited to airframe skins and structures, aircraft power units, naval and marine uses with salt-water exposure, industrial equipment where corrosion resistance and strength/weight ratio are controlling considerations, and applications requiring high strength and portability.

Looking at the future realistically, we see that titanium will be, for some time, a premium priced metal. Technical improvements in titanium-sponge manufacture, melting, and primary fabrication will bring future prices down by considerable amounts, but titanium probably will never be as cheap as aluminum or stainless steel. Titanium will find many applications wherever its high strength/weight ratio is important, as in transportation and moving parts; or wherever its superb inertness is important, as in chemical processing.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Excerpts from Discussion

J. H. Dunn, Aluminum Co. of America:

Are any titanium castings being used?

Parcel:

Castings are not now being produced because the affinity of titanium for carbon, oxygen, and nitrogen presents a tremendous problem in melting the metal for castings.

W. E. Jominy, Chrysler Corp.:

Does carbon increase the strength of titanium?

Parcel:

Carbon in titanium is like carbon in steel. Hard, free carbides form above the eutectoid, which improve the wear resistance but do not increase strength. Similarly, carbon up to about 0.20% increases the strength of titanium.

Parcel:

It has been said that titanium is poor in notch fatigue. Rem-Cru finds notch concentration factors of 2 to 3, which is not unduly high. Future improvements in surface finish, general purity, and freedom from defects may improve notch strength.

R. R. Teetor, Perfect Circle Corp.:

I'd like to know something about the mechanical properties of cast iron containing titanium.

Parcel:

We wouldn't know much about that because Rem-Cru is interested primarily in alloys containing at least 50% titanium.

C. O. Burgess, Gray Iron Founders' Society:

The effect of titanium in cast iron is like zirconium. In small amounts, it is a deoxidizer; in large amounts, titanium changes the graphite from flake to a fine eutectiform type.

L. L. Ferrall, Crucible Steel Co. of America:

Almost any shape available in stainless steel can be produced in commercially pure titanium and in most of the titanium alloys. Sheets have been produced in quantity in thicknesses down to 0.016 in. and in widths up to 48 in. Production of lighter gage sheets presents a problem in cold reduction. Larger ingots will have to be made, which can be slabbed and then rolled into thin sheets. Narrow strip, bars, and billets have had no production problems. Tubing ¼ in. in diameter with 0.012-in. wall thickness has been made from RC-70.

How to Select

NEW AIRCRAFT

for an Airline Fleet

Armin Baltensweiler, Chief Engineer, Swiss Air Lines Ltd.
and
Werner Guldimann, Aviation Consultant

Excerpts from paper "Economics of New Aircraft Selection" presented at SAE National Aeronautic Meeting, New York, April 22, 1952.

FACED with the problem of purchasing new flight equipment and of selecting one of the types available on the market, the management of an airline is primarily interested in the net income generated by a fleet of such aircraft over its total service life.

Therefore, the economic analysis and comparison between the competing types must be based upon figures representing the prospective net income generated by the fleets which are necessary to comply with network and traffic requirements. Furthermore, because the service life of different aircraft types is not always identical, the net income has to be reduced to unit time, that is to one year.

We propose the following procedure to arrive at the desired result:

1. The number of aircraft of any one of the competing types necessary to comply with the given or assumed traffic demand must be established.

2. The prospective operating accounts for each of the resulting fleets must be established and the net income figures compared.

3. As the whole calculation is based upon assumptions and estimates rather than objectively fixed values, some variations must be computed so as to grasp the influence of possible estimation mistakes.

To illustrate the method, let us take the case of a hypothetical small European airline. An existing fleet of 25 DC-3 aircraft has in the near future to be replaced by new equipment which is destined to serve the European short and middle range routes of the company. If possible—but by no means com-

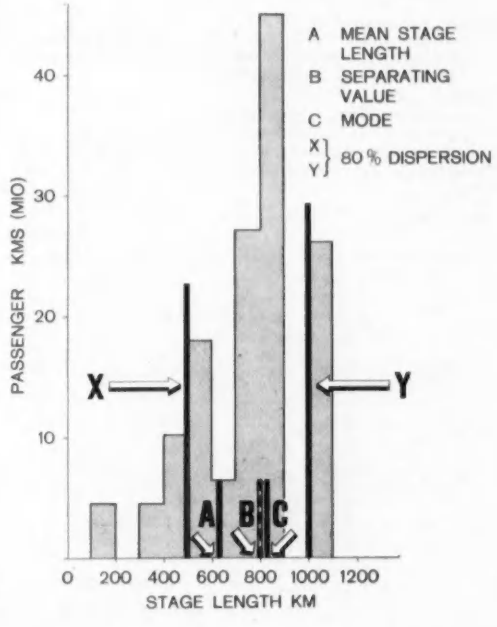


Fig. 1—Route structure and traffic demand for future base year

Table 1—Aircraft Types Obtainable on the Market

Type Designation	Mfg. Firm	Mfg. Country	Seats	Engines	Block Speed km/hr for 750 kms	Payload, lb
A	AA	R	28	2 Piston	300	7,000
B	BB	R	44	2 Piston	345	10,000
C	CC	R	50	4 Piston	355	15,000
D	DD	S	44	4 Turboprop	370	11,000
E	EE	T	44	4 Turbojet	480	12,000
F	FF	U	30	2 Piston	355	10,000
G	GG	S	28	2 Piston	345	8,000
H	HH	S	46	2 Piston	418	12,000
I	II	V	28	2 Piston	370	9,000
K	KK	W	28	2 Piston	345	9,000

Table 2—Checklist of Noneconomic Conditions Affecting Selection of Aircraft

Political Conditions
Currency Conditions
Financial Conditions
Safety Considerations
—crew compartment characteristics
—flight characteristics
—number of engines

Psychological Considerations
—origin from a source preferred or disliked because of previous relations and experiences (language, business practices, standards)

Co-operating Considerations
—correspondence with new aircraft to be acquired by neighboring companies with a view toward technical or commercial co-operation

Military Conditions
—convertibility to freighter duties
—possibility of operating over very long ranges
—spare parts logistics under wartime conditions

Meteorological and Climatical Conditions
Terrain
Radio Facilities
Airport Facilities

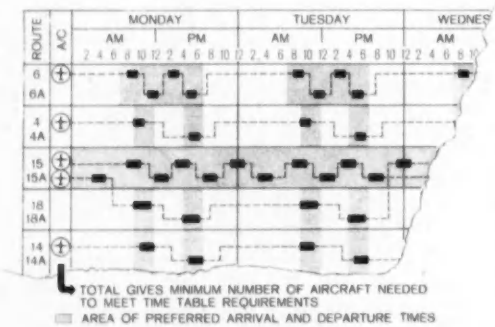


Fig. 2—Timetable requirements

pulsorily—the same fleet of new aircraft should be able to serve the middle and long range Near Eastern routes of the company.

Fig. 1 shows the assumed route structure and traffic demand for the future base year. Mean stage length is 630 km. About 80% of total traffic demand stems from stage lengths between 500 and 1000 km.

Table 1 shows the types of aircraft available.

Table 2 is a checklist of non-economic conditions affecting selection of the aircraft.

Without entering into details, we'll assume for the purposes of the present paper that the Types F, G, H, I, and K must thus be eliminated. Then, the four remaining Types A, B, D, and E must, together with the long range Type C already in use with our hypothetical airline, undergo a detailed economic analysis and comparison.

Evaluation of Fleet Size Figures

The number of aircraft of a given type which would be necessary to satisfy a given traffic demand over a given network is computed on the basis of total yearly traffic demand, mean number of passengers per aircraft, mean block speed, and yearly utilization of aircraft.

There are several variables in it. The number of passengers per aircraft depends on the load factor. For the time being, let us say this figure is fixed at 0.7. The mean block speed depends upon the mean block distance, which has, for the time being, been fixed at 630 km.

These figures being fixed, the minimum fleet size corresponds to the maximum utilization, and the maximum fleet size to the minimum utilization. Now, what we want primarily is not an exact fleet size figure but rather a reasonable fleet size interval and the variation of cost and revenue figures within it. Therefore, it would seem to be quite irrelevant exactly where we put those utilization values.

As a maximum utilization per year, we might take for example a figure of about 1900 hr, which is a quite satisfactory value in European conditions; on the other hand, general experience of European airlines confirms that a yearly utilization of 1200 hr or less is a minimum below which it becomes extremely difficult if not impossible to operate

economically. Based upon those two relative limits, we arrive for our hypothetical aircraft Type D at a reasonable fleet size interval ranging from 7 to 11 aircraft.

To get a third point defining the course of the required income curve, we consider the practical requirements of time table planning, interline connections, and preferred departure and arrival times. Then, we put first the flight hours preferable for each of the routes to be flown in a time table form, and then establish a time table for each of the competing types, which shows the possibilities of utilization and actually connecting the different services over the whole network. A sample is represented by Fig. 2.

By the way, this graph shows quite clearly the natural consequences of a radial network structure, which is general with most European airlines. It means that many different flights must be dispatched at about the same daily hours in different directions, and is an evident explanation why European utilization figures are as a rule so much lower than American ones.

Detailed Operating Account

The next stage of our examination consists in establishing a detailed operating account for each of the competing aircraft types, based upon the assumptions for network and traffic demand characteristics:

Yearly traffic demand	225,300 passenger seats
Load factor	0.7
Mean stage length	630 km

—and varying with different fleet sizes and correspondingly different yearly utilization figures.

For this purpose, we draw up a detailed account sheet in which we list the different items (Table 3). Table 4 contains the basic data independent of the aircraft type, Table 5 the basic data connected to the aircraft type investigated. In reality, absolute figures would of course be listed in such a table; to avoid misunderstandings and arguments, we decided to give but the relative values based upon the figures for aircraft Type A taken as unit.

The following might be said as to some of the individual items listed in Table 3 (Prospective Operating Account Sheet):

112: Empirically, the maintenance cost of a given aircraft type decreases during its service life, the decrease being caused by the favorable influence of aircraft modifications and growing personnel experience. As an additional influence, steadily increasing rationalization of maintenance work might be mentioned. Therefore, the total maintenance cost is subdivided into three periods.

113: Crew salaries are computed on an average figure for every crew member, with a mean flight time of 1000 hours per year, multiplied by the number of members, which varies according to the aircraft type. The possible influences of operating faster aircraft which

Table 3—Prospective Operating Account for Fleet of Eight Aircraft of Type D Having 1560 Hr Annual Utilization

	Expense per hour per aircraft	Expense per year per aircraft	Expense per year for fleet	Expense over service life of fleet, million francs
1. OPERATING EXPENSE				
11. Aircraft Operating Cost				
111. Fuel and Oil				37.3
112. Material and Labor				
1121. Material				11.3
1st 2 years				
2nd 3 years				
rmg 5 years				
1122. Labor				13.84
1st 2 years				
2nd 3 years				
rmg 5 years				
113. Crew Salaries				17.1
1131. Pay				
1132. Basic Salary				
1133. Insurance				
114. Insurance				
1141. Aircraft				12.8
1142. Liability				0.32
115. Depreciation				21.98
116. Interest on Investment				6.2
117. Route Cost				5.0
1171. Landing				
1172. Navaids				
118. Ground Handling				17.5
12. Passenger Cost				
121. Reservations etc.				0.5
122. Food and Supplies				9.0
123. Insurance				11.0
124. Miscellaneous				3.0
13. Initial Cost				
131. Personnel Training				0.5
132. Material				0.55
1321. Training aids				
1322. Tools, Buildings, etc.				
Total Fleet Operating Cost				167.9
⇩				
Fleet Operating Cost/Year, francs				16,790
2. OPERATING REVENUE				
Basic Revenue			44,373,000	
during service life			443,730,000	
plus 8% for two years			7,100,000	
Revenue during service life			450,830,000	
Revenue per year			45,083,000	
Ticket commissions etc.			4,508,000	
Net Operating Revenue				40,575
3. NET OPERATING INCOME PER YEAR				23,790

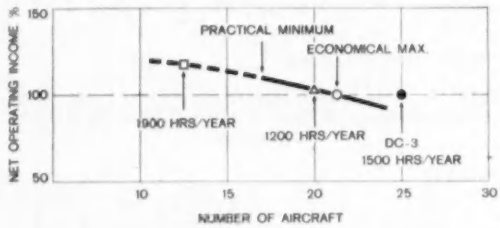


Fig. 3—Net operating income per year for Type A aircraft used over given network for given traffic demand compared to a basic fleet of 25 DC-3's—all operating at a load factor of 70%

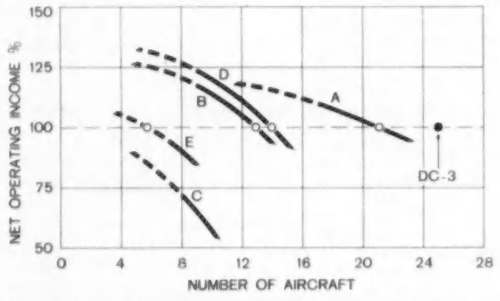


Fig. 4—Net operating income per year for Types A, B, C, D, and E fleets over given network for given traffic demand compared to a basic fleet of 25 DC-3's—all operating at a load factor of 70%

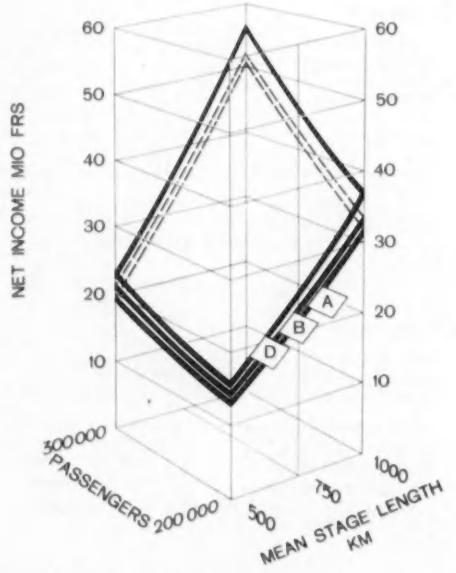


Fig. 5—For Types A, B, and D, net income as a function of passenger potential and mean stage length for a load factor of 70%

would tend to alter the km-pay unit were neglected in the present paper.

115: The depreciation computation is based upon the purchasing price of the fleet as a whole, including an additional percentage for the purchase of spares which varies according to the assumed utilization (35% for 2000 hr, 30% for 1600 hr, 25% for 1200 hr). Furthermore, an increment for tools is made. From the resulting sum, the residual value is deducted, and afterwards, ferry flight costs and customs taxes are added—which results in the total value to be depreciated over the prospective service life of the fleet. Depreciation of flight equipment is a very complex problem in itself —the authors permit themselves to refer to a paper which has been published by one of them in "Flugwehr und -Technik," September/October 1951.

116: The interest on investment is calculated on an annual basis of 4% of 70% of total investment.

117: Navaid costs are not calculated in the present paper. There are however cases in which they might play a certain role, and they are therefore mentioned as a reminder in our sample sheet.

131: The cost of personnel training and indoctrination depends somewhat on the fleet size and on the number of crew members which results therefrom, whereas the cost of brush-up training depends upon the service life as well as upon the intricacy of the aircraft type in question.

132: The cost of training aids, tools, and buildings depends on the one hand upon the intricacy of the aircraft type in question (independently of fleet size figures), on the other hand upon the tools and building accommodations already present. If there are buildings which must be constructed in connection with the purchase of a given aircraft type, their total service life must be compared to the prospective service life of the aircraft, and a corresponding part of the construction cost has then to be charged to the comparative operating account.

2: The operating revenue is calculated on the basis of the traffic demand figures which are the same for all competing types. An increment to the basic revenue has been made for aircraft types D and E because it is reasonable to expect a somewhat greater traffic demand due to the greater attraction which is exerted on the travelling public by turboprop and jet airliners. Therefore, we assumed an increase of 8% for Type D and of 12% for Type E during the first two years of operation. Ticket commission deductions have been assumed as 10% of the total revenue.

After having established the prospective net operating income per year for one of the fleet size figures, the procedure is repeated for the other two figures as well (using the appertaining utilization

data), which correspondingly leads to three different income figures for one aircraft type (Table 6). Thereby, the required course of the income curve within the assumed fleet size range is defined.

In Fig. 3, the curve is shown for Type A when used over a given network to satisfy a given traffic demand. Let alone the three utilization figures used to arrive at this result (1900, 1450, and 1200 hr), we are more interested in two points of the curve: The first happens to correspond to the middle figure used in the calculation and shows the prospective income with the minimum fleet size necessary to satisfy practical timetable conditions (practical minimum). The second one shows the fleet size necessary to generate the same income as the present fleet which has to be replaced (economical maximum).

Procedure Repeated for Each Type

Again, the same procedure is repeated with regard to every one of the competing types, finally resulting in Fig. 4 which very instructively represents and recapitulates the outcome of our investigation: The management of our hypothetical airline can expect the relatively biggest operating income by purchasing a fleet of Type D aircraft. The prospective income figures are somewhat smaller when a fleet of B or A aircraft is procured; whereas the income figures generated by a fleet of E or C aircraft would not even reach corresponding figures for present-day equipment.

Our investigation is however not yet finished, because it has thus far been based upon several estimations which possibly might prove to be mistaken by future developments. Particularly, oscillations of traffic demand, load factors and mean stage length might substantially alter the income figures. Therefore, we have to investigate the influence of variations

—of the yearly passenger seat demand between 200,000 and 300,000 seats
—of the mean load factor between 55 and 85%
—of the mean stage length between 500 and 1000 kms (simultaneously increasing yearly utilization from 1500 to 1870 hr)

Graph Gives the Answer

Fig. 5 compares the income curves for different aircraft types. This graph gives the management of our hypothetical airline a very satisfactory confirmation as to the superiority of aircraft Type D equipment for the given purpose.

Thus, we are finally able to answer the fundamental question put before the management of our airline with a relatively simple and rather unequivocal graph. But we must never forget that this answer is based upon quite a series of estimations and assumptions. To ascertain it further, it would seem appropriate and necessary to investigate the relative influence and importance of every one of these estimations and assumptions.

(Paper on which this abridgment is based is available in full in multilithographed form from the SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 4—Basic Values in Prospective Operating Account Independent of Aircraft Type

111.	Fuel and Oil Cost	
	Fuel: Gasoline	0.28 francs/liter
	Kerosene	0.25 francs/liter
	Oil	1 francs/liter
112.	Manhour Cost	6 francs/hr
113.	Crew Insurance	33% of pay
114.	Aircraft Insurance	6.8% of insurance value/year
121.	Reservations	0.22 francs/passenger
122.	Food and Supplies	4 francs/passenger
123.	Insurance	5 francs/passenger
124.	Various	1.80 francs/passenger
2.	Ticket Revenue	0.31 francs/passenger—km
	Ticket Commissions	10% of ticket price

Table 5—Basic Figures in Prospective Operating Account Varying with Aircraft Type

Note: The actual figures which would, of course, be listed in real cases have been reduced for the purposes of the present paper to unity for Type A and to relative values for the other types.

	Item	A	B	C	D	E	Basic Dimensions
111.	Fuel Consumption	1	2.3	3.5	3.3	9.8	liters/hr
	Oil Consumption	1	2	4	—	—	liters/hr
113.	Crew Members	1	1.7	2	1.7	1.7	persons
1141.	Aircraft Insurance Value	1	1.6	3.7	1.7	2.8	francs/aircraft
1142.	Liability Insurance	1	1.8	1.8	1.8	1.8	francs/aircraft
115.	Service Life	1	1	1	1.4	1.4	years
	Total Depr. Value	1	0.9	1.8	0.9	0.9	francs/fleet
	Residual Value	1	1	1	1.5	1.5	% of first value
1171.	Landing Cost	1	1.4	3	1.4	1.4	francs/landing
118.	Ground Handling	1	1.5	2.3	1.8	1.8	francs/handling

Table 6—Varying Fleet Size Prospective Operating Account for Aircraft D

		6 Aircraft, 2080 hr	8 Aircraft, 1560 hr	10 Aircraft, 1250 hr
1.	OPERATING EXPENSE			
11.	Aircraft Operating Cost			
111.	Fuel and Oil	37.2	37.3	37.3
112.	Material and Labor	26.27	25.14	25.14
113.	Crew Salaries	17.1	17.1	17.1
114.	Insurance	9.84	13.12	16.4
115.	Depreciation	16.76	21.98	27.53
116.	Interest on Investment	4.7	6.2	7.7
117.	Route Cost	5.0	5.0	5.0
118.	Ground Handling	17.5	17.5	17.5
12.	Passenger Cost	23.5	23.5	23.5
13.	Initial Cost	0.95	1.05	1.15
	Total Cost during Service Life	158.82	167.89	178.32
	Cost per year	15.8	16.9	17.8
2.	OPERATING REVENUE/YEAR	40.6	40.6	40.6
3.	NET OPERATING INCOME/YEAR	24.8	23.7	22.8

By

For Diesel Lube Ask the Engine

IN the early days of low-output internal-combustion engines, there was a period where automotive engines got along on almost any oil. With time, as engines were pushed up in power—and speeds were increased—the relative dimensions or heat-dissipating surfaces became smaller—crankcase capacities were reduced, engine temperatures rose, and lubrication problems inevitably made their appearance.

During the past 20 years diesel engines have increased in output per cubic inch of piston displacement over ten times. The diesel, always more difficult to lubricate than gasoline engines, presents new problems from year to year.

No wonder we face difficulties in the selection of suitable oils. The engine manufacturer has been called upon to tell the customer how to choose oils for satisfactory operating performance. This can be intelligently done only by a preknowledge of, and on field experience with, oils. He is asked to advise the user how to get out of trouble when he has difficulties that stem from lubricants or are allied with the problem of lubrication. The petroleum refiner must obtain information on the minimum requirements of engines in order to manufacture and sell suitable products intelligently to the user. The petroleum refiner and engine manufacturer eventually meet at the scene of the operator. Why not anticipate this event by cooperative effort at the very beginning of the cycle, behind the lines of attack?

Free-for-All Period

Experience shows, however, that the process of choosing oils has been far from cooperative. Go back, if you will, to the beginning of the automotive age—to the free-for-all period when the customer selected his oil on the basis of whim or price with no regard to service factors or engine idiosyncrasies. His actions were largely the result of ignorance of the facts due to the total divorce of the engine manufacturer and petroleum refiner.

Lists of Selected Oils

We then pass on to the era of recommended brands where manufacturers published a favored list of selected oils, usually based upon limited field experience with a few petroleum products.

When such lists became difficult to support in the face of aggressive oil marketers, base stocks or basic refining methods often became the criterion of selection.

Test Tube Era

This led to the test tube era, when viscosity, neutralization number, carbon residue, and color were the standard for measuring oil quality in an engine. Viscosity index became the all-powerful criterion for oil supremacy. Since we were worshiping at the throne of the test tube, the introduction of solvent-refined oil was already well paved. This was hailed as the perfect lubricating oil for everything, but it did not take long for us to find that, instead of bringing relief to the problems in high-output engines, these oils created new and different problems. While solvent-treated oils did produce outstanding improvements in many ways, it also became apparent that there was room for further improvements in engines that were designed to give high power

New Service Designations

FOR diesel users, the problem of deciding what oil to use is not a simple matter. History reveals many years of struggle in an attempt to find an adequate solution to this problem.

The author traces this history, bringing it up to date by a discussion of the newly developed API service designations for diesel- and gasoline-engine lubricating oil.

He shows how our old ideas of oil classification can be related to the new service designations, particularly for the diesel engine.

Problems: What It Wants!

C. G. A. Rosen, Caterpillar Tractor Co.

Excerpts from paper, "Let Service Choose Diesel Lubricants," presented before SAE Metropolitan Section, New York City, March 6, 1952

output. Even with the best of these new oils, wear became a problem in all engines, while ring sticking, piston deposition, galling or scratching of rings and liners, oil ring problems, and bearing corrosion seriously limited the operating time between major overhauls in diesel and high-output gasoline engines. To relieve these problems various mousemilk materials were tested. A solution was ultimately developed by combining the solvent-extracted oil with certain alloys or additives. The engine said that it was definitely a better lubricant because its useful life was extended. Here was introduced a new phase for selecting oils—"asking the engine what it wanted."

Approved Lists

In due course, Caterpillar issued an approved list of superior lubricants for Caterpillar diesel engines based upon laboratory and field tests. Then came General Motors with a recommended list of heavy-duty oils, and others followed suit. The Navy set up its 9000 series oil tests and the Army Ordnance Department set up a reviewing board to approve lubricants based upon certain acceptable test requirements. The Coordinating Research Council established the CRC designations used in specifying engine tests. This led to the introduction of the well-known heavy-duty types of lubricating oils, which eventually found their way into automotive equipment. In the mid-1940's the API established three designations for motor oils—regular, premium, and heavy duty—to provide a means by which the oil industry, the engine builder, and the consumer might have a pattern in recommending and applying commercial oils. Although these designations set out the differences in quality or performance characteristics, they failed to serve adequately the purpose for which they were originally intended.

After World War II the introduction of fuels of higher sulfur content and poorer grades led to the formulation of Series 2 and Supplement 1 oils for diesel engines. In heavy-duty automotive trucking services and in stop-and-go driving of automotive equipment it was found that Supplement 1 oils and, in some cases, Series 2 oils were palliatives for field service problems. The Army eventually cancelled out the 2-104B oils and introduced an oil of higher additive level—the MIL-O-2104 specifications—with the stipulation that they be qualified by the reviewing committee set up under the Ordnance Department of the Army.

For special services, such as the military, there may be continued reason for approval lists. We would all of us like to see this situation develop into the end use of service designations. Perhaps, in industry, occasions may arise for approval lists—we hope not—but where their necessity may reasonably arise the company or industry so involved will have to live through the experience at the challenge of its own competition. With closer cooperation between the two industries, the need for such occasions should become less and less.

Before leaving the approval system in the discard let us summarize the gains that this system has brought into being:

1. The emphasis of service performance has metamorphosed from the test tube to "asking the engine what it needs."
2. It has stimulated the development of the motor laboratory to undergird the chemist's test tube.
3. It has practically eliminated the engine manufacturer as a referee for petroleum troubles in the field.
4. It has provided minimum standards of performance levels for petroleum technical groups to implement their requirements of the petroleum manufacturing departments.
5. It has provided the customer with reliable information to guide him in oil purchases.
6. It has freed the engine manufacturer's service

department from the endless task of making routine tests of crankcase drains.

The main disadvantage of the approval system is the far-reaching influence that its decisions have had in services for which it never was intended to apply. In my own experience on the first "reviewing committee" approving oils for Army Ordnance 2-104B oils in 1944, I was evaluating oils on the basis of a Caterpillar piston—which today are "heavy duty" oils used in Cadillacs and Oldsmobiles. Why should I, as a diesel man, have been saddled with a responsibility that ultimately achieves the status of a specification for a high-powered automotive gasoline engine. Furthermore, it is true today that without the opportunity for industry to use OQ numbers or M numbers there are no teeth for enforcing the Reviewing Board's approval system in commercial service.

Service Designations

Eventually the time came when this hodgepodge means for selecting lubricants required clarification and simplification. With this in mind, the API Lubrication Committee at its meeting in Atlantic City in September, 1950, appointed a subpanel to consider the matter and make a report. One specific approach to the problem was stated as follows: "Define the designations in terms that will provide oil marketers, large and small, and engine builders with a practical and useful means of recommending and identifying minimum performance characteristics in each of several classes."

In February of 1951 Technical Committee B of ASTM organized a group with the directive to "appoint a special study committee to investigate immediately the confused situation on the proper use application of motor oils and to recommend the most practical approach to assure a prompt and effective solution of this problem." The instructions to this committee called for it to establish a general policy for action and not a detailed technical program. However, during the course of the year the program of the API Nomenclature Committee revealed a plan that was shared by the ASTM Special Study Committee. The API Nomenclature Committee evolved a system of "service designations," which eventually carried five groupings. The ASTM Special Study Committee was called in to provide definitions and explanatory information for the service designations. They were developed sufficiently comprehensively to be used ultimately as explanatory material for the SAE Handbook, and a report was presented by the ASTM Special Study Committe on Oct. 30, 1951, at Chicago. This report as submitted to the API Nomenclature Committee was used as a basis by them for a proposal to the API Lubrication Committee in such form as would be within the province of API to publish. The panel recommended the adoption of this system as proposed to the API Lubrication Committee at a meeting in Chicago on Nov. 7, 1951. It was voted unanimously to accept the proposal and submit it to the API Marketing Division for letter ballot. The final vote showed universal approval by the participating members.

There are many problems that the engine manufacturer must face that can only be resolved by a system of selecting oils on the basis of a service designation.

Take the diesel engine as an example. What are some of the factors that vary from engine to engine in design characteristics that influence lubricant selection?

1. Influence of base stocks and treatment on ring sticking as related to piston temperature.
2. Influence of combustion system on ring-belt temperature and deposits.
3. Influence of fuel sulfur content and end point on deposits and wear.
4. Influence of cylinder materials on wear.
5. Influence of design factors on piston-ring functioning and oil control.
6. Composite design influences affecting maintenance.

The service designations take further consideration of other operating factors such as:

1. Ambient temperature at both extremes.
2. Load.

Relation to Oil Classifications

How can we relate our old ideas of oil classifications to the new service designations? The chart (Fig. 1) applies to service levels and lubricants that such services require in diesel practice and reveals the logical growth of an evolving principle.

The left-hand column gives the service designations in the order of service severity, according to the API definitions:

1. Service ML—Service typical of gasoline and other spark-ignition engines operating under light and favorable service conditions, the engines having no special lubrication requirements and having no design characteristics sensitive to deposit formation.
2. Service MM—Service typical of gasoline and other spark-ignition engines operating under moderate to severe service conditions, but presenting problems of deposit or bearing corrosion control when crankcase oil temperatures are high.
3. Service MS—Service typical of gasoline or other spark-ignition engines operating under unfavorable or severe types of service conditions, and where there are special lubrication requirements for deposit or bearing corrosion control, due to operating conditions, or to fuel or to engine design characteristics. (This does not preclude the use of this classification for diesel engines.)
4. Service DG—Service typical of diesel engines in any operation where there are no exceptionally severe requirements for wear or deposit control due to fuel or to engine design characteristics.
5. Service DS—Service typical of diesel engines operating under extremely severe conditions or having design characteristics or using fuel tending to produce abnormal wear or deposits.

The horizontal axis measures the capacity of a lubricant to satisfy specific service requirements: in this case, the measure is oil life or acceptable oil change hours.

For a diesel engine under light service severity factors as indicated on the extreme right of Fig. 1, a premium oil of the old classification may well

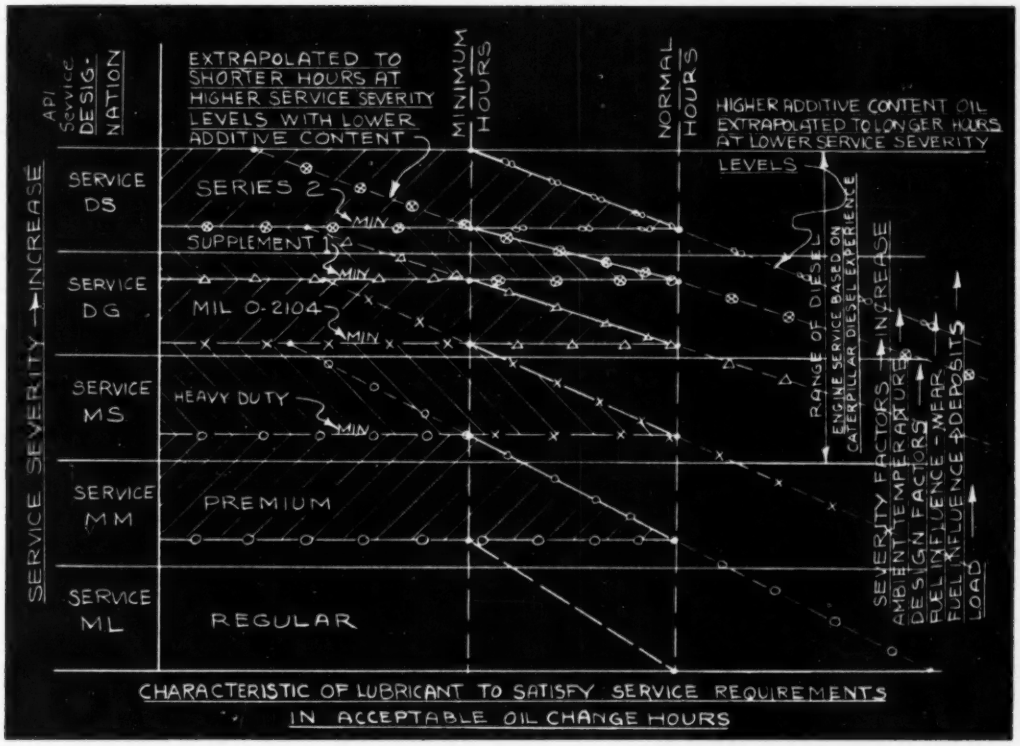


Fig. 1—Schematic relation of service designations to oil classifications

satisfy operating conditions at such a low service severity level. The oil may, however, require changing close to the minimum range of hours.

Increase of any given service severity factor, such as ambient temperature or load, may raise the level of severity to require an oil in the range of the heavy-duty or 2-104B classification and thus extend the oil life to normal hours of crankcase drain.

Again the service severity level may be increased by fuel factors responsible for deposits unless oil change periods be reduced as per the sloping line. This reduction may make it economically advisable to enter the next higher range of oil capacity to serve at longer hours in the MIL-O-2104 range.

Design factors, or a combination of factors, may be such as to raise the service severity level into the Supplement 1 range of oils to yield desirable oil life. The added burden of burning high sulfur fuels in some designs of engines may require Series 2 oils or, as in the Navy where the Supplement 1 types of oils may only be available, such engines may be required to operate on shorter drain periods, as expressed by the extrapolated dotted line to the left.

On the other hand, a reduction of any service severity may permit the use of oils of higher additive content extrapolated to longer hours of oil life, as shown by the extended lines to the right of the normal hours range.

Fig. 1 is a purely schematic arrangement to illustrate a point, and is not to be construed as an accurate evaluation scale of oil performance at any given service level. The experience behind this particular chart is primarily on Caterpillar diesel engines.

These service designations comply with the dictum of H. C. Mougey in his letter of June 15, 1950 as a prelude to the General Motors list of heavy-duty oils, "The requirements for engine oils vary, depending upon the service conditions. The final measure of quality of an oil is its performance in service. The responsibility for the lubricant's quality and performance in service must remain with the oil company making the lubricant."

The export service manager of Caterpillar has recently made this statement: "You are probably aware that our lubrication requirements have become somewhat complicated with recent developments of new lubricating oils by the petroleum industry, new developments in our own engine designs, and a changing fuel supply in various parts of the world. We have found it necessary to publish lists of approved brand names of lubricants in order to guide our customers to the proper type of oil they should use under given conditions. We

have known of no other way to give recognition to an oil as regards its most practical usefulness. This is especially true in export territories, where local oil merchants may not know or care about the severity of service for which their various brands might be most adaptable. There is a crying need for a new system for the selection of satisfactory lubricants. When we recommend SAE 10 oil for low-temperature operations and SAE 30 for temperatures above freezing, it is understood in every language in every corner of the world. If oils were similarly classified as regards their ability to withstand light or severe service it would simplify lubrication recommendations and assure the customer of the opportunity to select the oil most practical for his operating conditions."

Everywhere there is ample evidence for the need for a change, for the ultimate achievement of a system that will satisfy the needs of the consumer at the scene of his operation. The key to the solution of the problem can only lie in the cooperation of the automotive and petroleum industries on the basis of:

(a) Mutual trust.

(b) The use of a common language in dealing with the consumer.

(c) The utilization of an understandable tool of expression between the two industries.

With these precepts ever before us there is no reason why we can't get together on a cooperative basis in understanding the customer's problems, whenever such problems may arise, by:

(a) Determining minimum requirements where needed for engines, understandable by both industries and translatable into a common language by means of an accepted and proved tool.

(b) Evaluating the economic factors in providing satisfactory service at desired performance levels.

The ASTM Special Study Committee recently endowed with the powers of a steering committee, is dedicating itself to this high purpose. It is very important that the classification be considered as a method of designating "service requirements" and not an oil classification. The immediate problem is to facilitate the transition from thinking in terms of former API oil classifications and classifications based upon military specifications to the new concept of service designations and of oils suitable for these services. We hope, however, to retain and conserve the assets gained through the years. We can't afford to throw completely away what we now have until the process of education by both industries brings the customer up to the point of takeover the new plan. It is, furthermore, necessary to provide a means by which engine manufacturers, oil refiners, and consumers can exchange information and data on the service performance of oils without continued recourse to the oil classifications formerly used. The results obtained using an information exchange system would not be subject to formal review by an approval board or similar agency, but compliance with the needs for a particular service classification would be the responsibility of the lubricant supplier. The need for establishing minimum performance criteria for new equipment, or to solve service problems, involves consideration of test methods pertinent to each significant engine service factor and would be influenced by the particular test procedures agreed upon—this in order to permit choosing an oil to suit a service.

Under conditions of stress the engine manufacturer or automotive industry is faced with the possibility of using one of three methods to advise the consumer concerning oil selection:

1. Specifications.
2. Approval lists.
3. Exchange of information understandable by both industries and utilizable by the oil marketer.

We don't want specifications and we hope we won't need oil approvals. As a long-range program involving perhaps five or ten years for its consummation, a third phase should be set up as a goal. It is felt that ASTM would be interested in establishing minimum service requirements for lubricants if measured on an instrument that could be considered as an adequate tool, thereby placing in the hands of engine manufacturers and petroleum refiners a "common language" for understanding the requirements of automotive equipment. It is felt that a tool could be developed that did not involve a commercial engine but that would correlate with mass evidence gathered on present types of test engines, and in the future could be used to evaluate field problems and new designs.

In other words, an engine manufacturer would bring his problems in from the field or evaluate the requirements of new equipment and correlate them on an accepted test instrument that would yield numerical values on possibly individual tests determining numerical values for deposits, numerical values for bearing corrosion, evaluation of low-temperature problems, and numerial determination of wear. The scheme would permit the engine manufacturer or automotive industry to present to the petroleum industry knowledge of the minimum requirements for each of these factors considered acceptable for good engine performance. The petroleum refiner in turn would evaluate his product in relation to these minimum requirements and sell his product under his own brand names in full confidence that they satisfy service requirements without the necessity of going through extended approval tests or other arbitrary evaluation of quality control.

To achieve this ultimate goal, consideration should be given to the development by CRC of a special test engine or engines or possibly other devices that would serve as instruments or tools for measuring performance characteristics suggested above, similar in principle to the system employed in ascertaining octane ratings on gasoline. Solution of this long-term problem involves adequate studies by a group such as the ASTM Special Study Committee to make the surveys and assist in setting the goals toward which the CRC engine development group should steer its course. Solution of this long-term problem involves the investigation of engine design, operating procedures, and methods of grading the results, preferably in numerical units, and the correlation of existing test methods with the new tool.

In breaching the gap from the present phase of promulgating the use of service designations to the

ultimate goal of establishing minimum performance criteria by a mutually acceptable test instrument an intermediate phase is essential to guide our course to the ultimate goal. In the words of the chairman of Technical Committee B, W. S. James: "There is much to be done in learning how to describe the engine service classifications and I am sure that ideas on tools or instruments to clarify these service demands in terms of petroleum products would be welcomed by the API Lubrication Committee. This is a field in which close and sincere cooperation between the automotive and petroleum industries would be very valuable."

To consummate this program requires that both industries cooperate to the fullest in achieving an ultimate answer. A golden opportunity is ours now.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Planes Take on Plastics . . .

. . . because new synthetics offer adequate properties at reasonable price, particularly in resisting heat. Plastic tooling helps save production dollars.

BASED ON PAPERS BY **R. L. Whann,** North American Aviation, Inc. **C. R. Lemons,** Douglas Aircraft Co., Inc. **G. J. Walkey,** Lockheed Aircraft Corp.

PLASTICS have gone over with aircraft engineers for at least two reasons: First, scarcities of certain conventional materials have forced a search for replacements. Second, because plastics are man-made synthetics, needed properties can be built into them.

Aircraft men have recognized limitations of plastics. But they also recognize these materials' plus values . . . weight saving, electrical and thermal insulation, attractive appearance, chemical and corrosion resistance, toughness, abrasion resistance, and often cost savings.

The chief type plastics used in the industry and their advantages, says Whann, are as follows:

- **Glass Fabric Laminates:** These have special properties, such as dielectrics, thermal insulation, and high specific strength. They can compete with metals in short production runs and on complex shapes. Their main use is in radomes. Laminated plastics also are going into complicated heat and vent system ducts.
- **Post Formed Phenolic Laminates:** These materials are available in sheet, rod, and tube form. They're characterized by light weight, toughness, resiliency, corrosion resistance, good dielectric properties, and low fabrication costs. In machined forms they are used in aircraft as electrical insulation blocks, cable fairleads, rubbing strips, and spacer and filler blocks. In post formed shapes are parts like cable guards, ammunition chutes, map and data cases.
- **Compression and Transfer Molded Plastics:** These materials, have properties much like those of laminated plastics. They are used in parts with intricate shapes, impractical to machine. Injection molded and extruded plastics knobs, transparent covers, boxes, sleeving and shielding for electrical wire and conduits.

Today aircraft men are focussing more than normal attention on heat resistance. That's because aircraft and guided missiles are running more and more into high temperature conditions. Lemons points out that fitting into this particular picture are fiberglas laminates using several types resins, as well as transparent plastics.

The main item in reinforced plastic determining the material's strength and temperature resistance is the resin.

Phenolic resins have the highest physical properties up to 500 F. Fiberglas laminates made of Cincinnati Testing Lab's CTL-91LD resin have a bending strength of over 50,000 psi at room temperature; it drops about 35% to 35,000 psi at 500 F.

Second place goes to polyester resins. They have physicals about the same as phenolics at room temperatures, but the properties drop off quickly with rising temperature. Laminates made with Naugatuck Chemical's Vibrin X-1047 have about the same strength as 91LD laminates at room temperature, but it drops about 55% to 20,000 psi at 500 F.

Silicone laminating resins, such as Dow Corning's 2104, may have only half the flexural strength of the two previously mentioned resins at room temperature, but it maintains its strength longer at temperatures over 500 F.

Plastics have worked themselves into the aircraft plant as well as the factory's product. The stuff has been a cost saver in tooling such as dies, check fixtures, and master tools.

Take a stretch press die 4 ft × 15 ft × 3 ft. It weighs about 35,000 lb in kirksite, only about 3500 lb in plastic. Molds for glass laminates have been made costing $600 that replaced a kirksite mold costing $5000.

One aircraft maker went to plastic tooling for complete assembly and fabrication of air intake ducts on a master model fighter plane. Double action draw and drill and assembly fixtures were made of plastic. The tooling job took half the time and one quarter the dollars needed for a similar project tooled with conventional metals.

(Papers "Plastics in Aircraft" by Whann; "Elevated Temperature Resistance of Plastics" by Lemons; and "Plastic Tooling in Aircraft Manufacture" by Walkey, were presented at SAE Southern California Section, Los Angeles, March 25, 1952.)

Cylinder Wear— How to How to

BEFORE it is possible to evaluate the ability of an oil to reduce engine wear, it is necessary to develop accurate, reproducible ways of measuring wear. Then, armed with this technique, one can study various ways of reducing wear to see which are most effective. Both phases will be discussed.

How to Measure Wear

There are three ways of measuring wear: physical, chemical, and radioactive.

The physical method is the oldest and most direct way. First, the parts being studied are measured very accurately. Then they are installed in an engine that is run for a relatively long time under selected test conditions. At the completion of the test, the parts are again measured. The difference between the final figures and the initial ones represents the amount of wear.

Unfortunately, this method is somewhat lacking in accuracy and, if the parts being tested have any reasonable life, most time-consuming. For example, liner wear rates of less than 0.002 in. per 1000 hr are considered desirable in a certain make of diesel. Since measurements of liner diameter much closer than 0.001 in. are difficult to make, at least 500 hr is required for a single wear test.

Then, if we try to repeat this test, using a new piston and liner of the same design and, let us say, from the same production lot, we will find that the amount of wear occurring under the same test conditions will not be the same, even within the accuracy of our micrometer readings. Minor differences in surface finish, hardness, or mechanical fit

Engine Wear Is Mighty Expensive

ENGINE wear costs the American people at least a billion dollars a year.

Part of this money goes for the repair of badly worn engines. (One survey of garages and engine rebuilders showed that 57% of the cars being overhauled were brought in solely because of excessive wear and in another 28% wear was at least part of the trouble.)

The remainder represents the value of cars that must be junked because it is no longer economically feasible to repair the engine, even though the rest of the car isn't worn out. (As a matter of fact it has been found that, on the average, a car's engine lasts only half as long as the rest of the car—except for such expendable items as brakes.)

This condition does not mean that the automotive industry is not alert to finding ways to reduce wear. Air cleaners, oil filters, better wearing cylinder and ring materials are just some of the developments being used to lower the rate at which engines wear.

At the SAE Summer Meeting representatives of several oil companies showed that the petroleum industry is also trying to lower wear rates —by means of better oils—and oil additives.

They discussed the problem in two steps. First, they considered ways of measuring wear—including the newly developed radioactive technique. Then they showed how these techniques are being used to evaluate the wear reducing properties of various oils and additives. A summary of these papers and the accompanying discussion is presented herewith.

Measure It Reduce It

can make large enough differences in wear rates to spoil the reproducibility to some extent. Vagaries in the break-in process and even differences in the torquing of the units can add to the uncertainties.

For designers of engines and their component parts, however, this is frequently the only applicable method. To test a new design of piston ring, for example, the engineer has little choice but to put the ring into an engine and see how long it lasts.

Recently, the limitations of the physical method have encouraged those interested in the effects of fuels, lubricants, and operating conditions on engine life to develop quicker and more precise methods of making the measurements—methods that do not require that engines be disturbed for cylinder measurements or for gapping or weighing of rings.

The first of these new methods consists of analyzing the used oil for the iron worn from the moving parts of the engine. The method owes its precision to the fact that as little as one-tenth part of iron per million can be detected in lubricating oil, and iron contents of 5–100 parts per million can be determined with an accuracy of 5–10%. Translated into terms of cylinder and ring wear, this corresponds to the measurement of a change in cylinder diameter of seven millionths of an inch, with an accuracy of three or five ten-millionths of an inch.

The high sensitivity of the method allows significant wear values to be obtained in short tests—of 50–100 hr. Furthermore, the engine need not be dismantled to obtain the measurements. Thus, mechanical factors such as surface finish, break-in, and distortion can also be practically eliminated as variables affecting wear results. Also, a large number of tests can be made in the same engine between the time it is broken in and the time it is worn out, under practically constant mechanical conditions.

This method presupposes that:

1. All iron in the oil originates from cylinder and ring wear.
2. All oil lost by normal consumption carries with it an aliquot of iron proportional to the bulk crankcase oil concentration.
3. Engine sludge deposits do not contain high iron concentrations.

According to Ellis-Edgar, the most direct and

Based on papers:

How Engines Wear

By J. F. Kunc, Jr.
D. S. McArthur
L. E. Moody
Standard Oil Development Co.

Critical Lubrication Areas in an Engine

By V. G. Raviolo
Ford Motor Co.

Wear Measurements by Physical, Chemical, or Radioactivity Methods

By C. C. Moore
W. L. Kent
Union Oil Co. of Calif.

Engine Wear—Comparison of Radioactive Wear and Field Measurements

By F. W. Kavanagh,
California Research Corp.

Laboratory and Field Wear Tests Using Radioactive Tracers

By H. R. Jackson
Atlantic Refining Co.

Effect of Heavy-Duty Oils on Engine Wear in Typical Passenger Car Service

By J. L. Palmer
Lubrizol Corp.

Wear Prevention by Alkaline Lubricating Oils

By J. C. Ellis
J. A. Edgar
Shell Oil Co.

Presented at SAE Summer Meeting, Atlantic City, June 4, 1952.

These papers will be printed in full in the 1953 SAE Transactions.

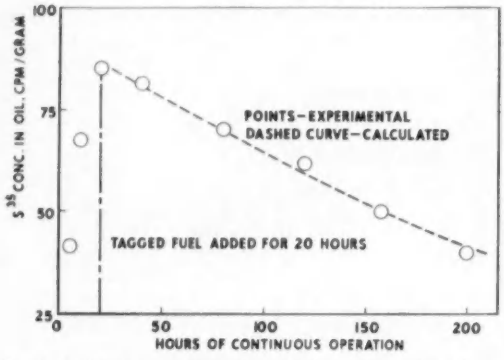


Fig. 1—Predicted versus observed loss of fuel sulfur products from crankcase oil laboratory diesel engine (from Ellis-Edgar)

simple answer to No. 1 is to determine an iron balance, but to do this, they said, requires confirmation of No. 2. They accomplished this in a laboratory diesel engine by operating for 20 hr on a fuel containing the radioactive sulfur isotope S^{35}. Any radioactive sulfur that is found subsequently in the crankcase oil, then, they considered to have originated in this fuel. This sulfur may be unchanged from the organic form it had when added to the fuel or it may be in an altered organic form as a result of reaction with fuel or oil hydrocarbons and oxygen or it may be combined with the metallic oil additives and with iron corroded from the cylinders.

At the end of 20 hr, the radioactive diet was suspended, and the engine ran for 180 hr more with normal fuel. The decline in radioactivity of the crankcase oil was carefully plotted during this 180-hr period because it represented exactly the rate of loss of corroded iron from the crankcase oil (as well as loss of other sulfur compounds that had been deposited during the first 20 hr).

These authors found that the loss of these sulfur compounds was at a rate almost exactly equal to the product of the rate of oil consumption times the concentration of sulfur in the oil, as shown in Fig. 1. In this figure the dashed line depicts what the loss in activity (counts per minute, "CPM") would be if sulfur were lost in aliquot with oil; the circled points are Geiger counter readings.

They considered this to be conclusive proof that the oil lost by consumption processes from the crankcase carries with it all of the iron that existed in the oil at the instant it was consumed. Corrections to the measured iron content of the crankcase oil were made accordingly.

They made an iron balance, based on the measurements of accumulated iron in the crankcase oil, after correcting for iron lost through consumption. This was accomplished in their laboratory diesel engine during overhaul and reconditioning by accurately measuring the cylinder dimensions and piston-ring weights. Cylinder bores were measured with a Caterpillar wear gage and profiles were determined in four positions.

The engine was then operated on the testing schedule for 2072 hr. All operation was at full load and constant speed, although fuel quality, lubricating oil, and cylinder jacket temperatures were varied during various portions of the total test. During this period the engine was stopped nine times for reasons common to all such operations but, in so far as possible, operation was continuous, oil changes and flushings being made "on the fly."

At the conclusion of the test, cylinder bores were remeasured and piston rings reweighed. Also, a complete summation of all chemically determined iron, corrected for consumption losses, was made. These results are summarized in Table 1.

These investigators feel that this agreement is particularly good, considering the possible errors inherent in such measuring techniques. The conversion of bore measurements to iron loss by integration of four wear profiles is, of course, an approximation, although a good one, so they believe.

They have found that the chemical iron determination by the colorometric method is applicable with good repeatability, but nonuniform sampling may cause errors from this source. To investigate this possibility, that is, that engine deposits may contain high concentrations of iron, they collected samples of sludge deposits from various sections of the engine and subjected them to analysis. In no instance were iron contents of these samples appreciably different from those of the bulk crankcase oil at the time of the sampling.

These results provide, they concluded, considerable evidence to prove that:

1. All iron present in the crankcase oil samples originated from the cylinder zone.
2. All oil lost by processes of consumption carried with it an aliquot of iron proportional to the concentration of iron in the bulk crankcase oil.
3. Engine deposits did not contain high concentrations of iron.

The other new method of measuring wear consists in using radioactive piston rings. This technique is already popular because of its extreme sensitivity, so that changes in wear rates occurring in a few minutes or a few hours can be readily measured. Thus, the effect of a large number of operating variables can be determined in a short time, measurements that might have required years to make by direct physical methods. The effects of transitory phenomena, such as the effect of changing from an oil of high wear rate to one of low wear rate, can be observed, which would be impossible to detect by any other method. It is estimated that the radioactive method is several hundred times more sentitive than the iron analysis method. It would be almost ridiculous to think of measuring a tenth of a millionth of an inch by direct physical means.

The radioactive technique offers an advantage over the iron analysis method in that there is no question as to where the iron in the lubricating oil came from. It can only come from the radioactive part, usually an irradiated piston ring.

This fact may also be a disadvantage, for it is often assumed that the wear rate of the piston ring is the same as the wear rate of the cylinder wall. Such a one-to-one relationship between ring wear and cylinder-wall wear is not necessarily true. One can speculate that, under conditions of corrosive wear, large areas of the cylinder wall are exposed to the corrosive gases. The piston ring, on the other hand, is in contact with the cylinder and is rela-

tively protected from the corrosive gases. Therefore, it might be expected that cylinder wear would be higher than ring wear under some circumstances.

In many cases the rate of wear on the top ring is of the same order of magnitude as the rate of wear on the cylinder. There are, however, data to show that, under low jacket-temperature conditions and with high sulfur fuels, a certain oil effected a substantial reduction in top ring wear over that obtained with a reference oil, whereas the reduction in cylinder wear with this oil was relatively minor.

The high sensitivity of the radioactive method can be a disadvantage from another point of view. Because wear values may be obtained with such short runs, there is a tendency to overlook the influence of oil deterioration on wear rates. In longer tests, such as are normally run when measuring wear by iron analysis, or by direct measurement, the average wear rate with an oil over its period between oil changes is obtained.

There is no question but that the radioactive method of measuring wear is very precise and has opened up new fields of engine research. It does require elaborate preparations for a test, such as irradiating the ring and providing special equipment and safety precautions for handling the "hot" engine and oils. The iron analysis method can be applied to any engine in the laboratory or in the field on a moment's notice merely by setting up the test conditions and taking the oil samples.

Each of the wear methods discussed has its field of application: the physical method for mechanical studies, the radioactive method for studying operating conditions or fuels and lubricants problems, and the iron analysis method for ready application to the latter problems. Wear rate measurements by direct physical methods are, in a sense, the fundamental values on which the radioactive and iron analysis measurements are based. Both of the latter methods have been proved to be valid by checking against the physical method.

Kavanagh, in particular, told how radioactive measurements were compared with field results.

Three oils were used in a laboratory engine operated under FL-2 conditions with radioactive rings. These conditions are usually considered representative of slow-speed, stop-and-go driving. Fig. 2 shows the results. It will be noted that the wear was essentially linear with heavy-duty oil A. The premium oil was better than the former oil early in the test but became poorer when it had been used too long. Heavy-duty oil B maintained much lower wear than the other two oils throughout the test period, but the slope of the curve after the 20-hr point (equivalent to about 1000 miles) indicates that the additive had been consumed.

Table 2 shows the cylinder wear measurements he obtained from the taxis after they had been operated with the three oils also used in the lab tests.

The author points out that the field test data shown in this table are exceptionally reproducible. The spread for the three points with the premium oil is only 10%. Only two of the eight points with heavy-duty oil A are below 0.0018 in. per 10,000 miles, while with heavy-duty oil B only seven of the 21 points are above 0.0010 in. per 10,000 miles.

These taxicabs were all used in normal city serv-

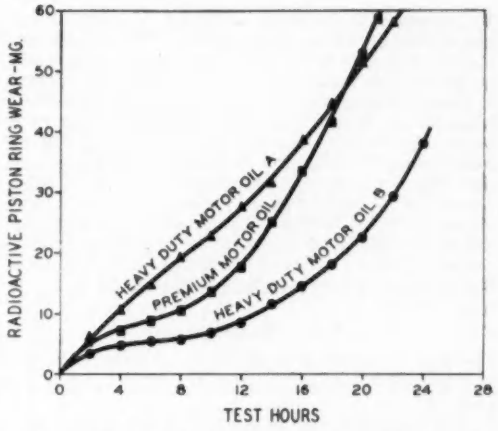


Fig. 2—Radioactive piston-ring wear—Chevrolet FL-2 conditions (from Kavanagh)

Table 1—Comparison of Physically Measured and Chemically Determined Iron Wear (from Ellis-Edgar)

(Laboratory diesel engine, full load, constant speed, continuous operation, except for required shutdowns for routine maintenance.)

Cylinder Number	1	2	3	4	Total
Ring Wear, g	5.72	6.14	6.06	2.46	20.38
Bore Wear, g	14.50	14.40	15.85	12.05	56.80
Total	20.22	20.54	21.91	14.51	77.18

Summation of Chemically Determined Iron in Crankcase Oil, 73.1 g

Table 2—Cylinder Wear in Taxicab Service (from Kavanagh)

1. With Premium Motor Oil

Cab No.	Average Cylinder Wear, in. per 10,000 miles
1	0.0021
2	0.0021
3	0.0019
Average	0.0020

2. With Heavy-Duty Motor Oil A

Cab No.	Average Cylinder Wear, in. per 10,000 miles
4	0.0027
5	0.0018
6	0.0033
7	0.0011
8	0.0013
9	0.0042
10	0.0018
11	0.0026
Average	0.0023

3. With Heavy-Duty Motor Oil B

Cab No.	Average Cylinder Wear, in. per 10,000 miles
12	0.0010
13	0.0006
14	0.0006
15	0.0009
16	0.0014
17	0.0011
18	0.0011
19	0.0007
20	0.0008
21	0.0011
22	0.0006
23	0.0009
24	0.0008
25	0.0009
26	0.0009
27	0.0009
28	0.0008
29	0.0008
30	0.0016
31	0.0012
32	0.0014
Average	0.0009

ice through their usual overhaul periods, which amounted to 30,000–50,000 miles. The laboratory and field data are compared in Fig. 3. Kavanagh considers this figure to be proof of the correlation of laboratory versus field results for the products employed in these tests. This correlation was best where the 16-hr points from the laboratory engine were compared with the field data. He cautioned that Fig. 3 should not be interpreted as proof of a general correlation between piston-ring wear and cylinder wear. It merely illustrates, he said, that the wear rates of the rings in the laboratory engine as influenced by lubricating oil type correlate with wear rates of taxi cylinders using the same oils.

How to Reduce Wear

There are three general types of wear (Fig. 4):

1. Friction, which is caused by metal-to-metal contact.
2. Abrasive, which is caused by dust, dirt, and other solid particles in the air intake.
3. Corrosive, which is caused by chemical attack of the metal surfaces by corrosive constituents and moisture formed in the combustion process.

A friction surface is relatively smooth. It is caused by a lack of or inadequate lubrication.

An abraded surface is heavily ridged.

A corroded surface is completely covered with pock marks and craters. Kunc et al found in their lab tests that these marks are not erased by even 100 hr of operation under noncorrosive conditions.

In discussion, however, J. P. Stewart, Socony-Vacuum Laboratories, suggested that in average, over-the-road operation, this time is much lower, of the order of 5 hr or more.

Presumably, during this time—whatever its length—the corroded surfaces are smoothed, corrosion products are scrubbed away or the ring surfaces abraded by the debris from such action. This phenomenon occurs, Stewart added, with an increase in cylinder-wall temperature as well as with a change in oil type, the usual comparison.

Which type of wear predominates appears to depend, to some extent, on the operating conditions of the engine. For example, high rates of wear—corrosive wear—universally occur in door-to-door delivery service, which is characterized by low operating temperatures, frequent stops, and a high proportion of cold starts. Corrosive wear is less pronounced, on the other hand, in heavy-duty service, such as long haul, highway transport usage in which engine operation is best matched to conditions giving low wear.

There was considerable disagreement, however, on the relative importance of the various types of wear in average field service. Kunc et al contended that friction is the principal cause of wear, with mild abrasion second in importance. In their field tests, low-temperature corrosive wear was observed in only 10% of the engines.

On the other hand, others considered corrosive wear to be the biggest troublemaker. Ellis-Edgar suggested that the following conditions are most conducive to corrosive wear:

1. High load factors.
2. Low cylinder-wall temperatures.
3. Fuel of high sulfur content (1% or more).

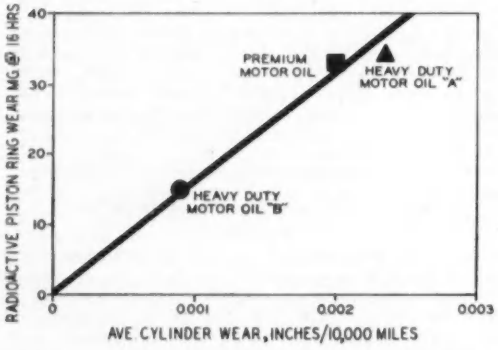


Fig. 3—Correlation of laboratory radioactive piston-ring wear and service (from Kavanagh)

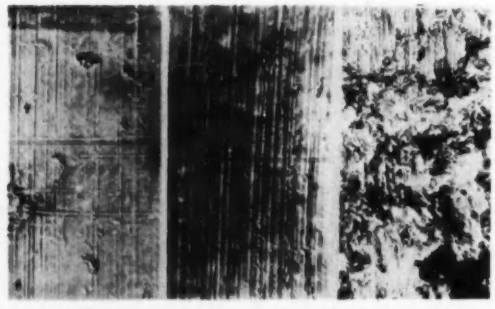


Fig. 4—Laboratory ring surfaces after being subjected to various types of wear: (left) friction, (middle) abrasion, (right) corrosion (reduced from photomicrographs taken at 440×) (from Kunc, McArthur, and Moody)

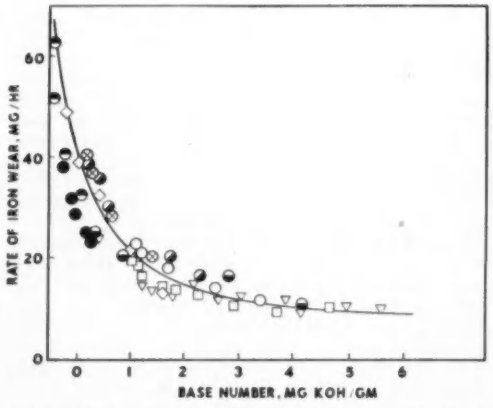


Fig. 5—Wear rate versus base concentration for various lubricating oils —laboratory diesel engine, full load, 1% sulfur fuel, 100 F cylinder jacket temperature (from Ellis-Edgar)

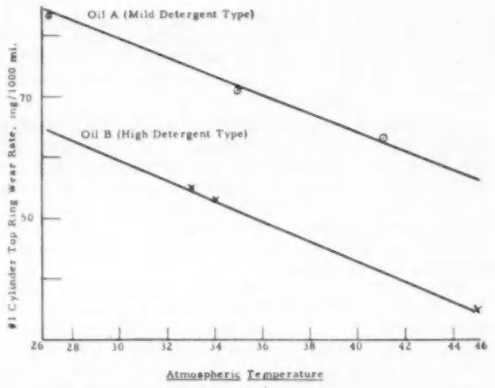


Fig. 6—Relative wear of oil A versus oil B in passenger-car service—varying atmospheric temperature—average trip length of 5 miles (from Jackson)

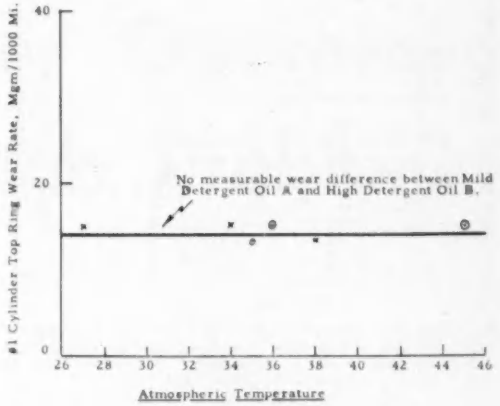


Fig. 7—Relative wear of oil A versus oil B in passenger-car service—varying atmospheric temperature—average trip length of 19 miles, high thermostat, winter front (from Jackson)

Stewart looked at it a little differently. He asserted that as far as gasoline engines are concerned both friction and corrosion wear must occur in service, for operating temperatures likely to produce both types of wear are experienced alternately on the road. Moreover, he feels that corrosion is a major, if not the major, source of ring and cylinder wear, even in engines normally considered as being operated under heavy-duty or high-speed service.

His version of the wear cycle in normal commercial operation is as follows: a high rate of corrosion wear during the starting and early warmup period, followed by a "healing" period at higher than average wear for some time after normal load and operating temperatures have been reached.

Even though an engine is operating under optimum conditions 95% of the time, he considers that 50% of the wear would be of this type over an 8-hr operating period. Under less favorable operating conditions corrosive wear would be even higher. So, he raises the question, "Would not the rings at the end of such an 8-hr operating period exhibit the wear pattern diagnosed by Kunc et al as the resultant of 'frictional' wear?"

It is desirable to know which type of wear is occurring in a particular operation because the method of wear reduction varies with the type.

Abrasive wear is reduced to a minimum by the use of properly maintained oil filters and air cleaners. Particularly effective is the full-flow filter system, for it removes abrasive particles in the oil much more quickly than the bypass system does, so that there is less chance of their causing wear.

Corrosive wear, on the other hand, can be brought under control by the use of oils of high alkalinity. Ellis-Edgar demonstrated this with laboratory results (Fig. 5) and with the results of several tests of engines operating under severe conditions, where heavy-duty oil was replaced by oil of high alkalinity.

In two fleets they studied on the Pacific Coast, wear rate was, in general, reduced a little more than 50% by the use of highly alkaline oil, as compared with the use of heavy-duty oil. Wear rates with this lubricant were reduced to such an extent that a bore life of 60,000–100,000 miles was indicated.

One of these fleets consisted of seven engines in city utility service. The other contained six engine makes in the 200–240 cu in. class and was used in city delivery operation.

They experienced similar results when 10 diesel engines were run with highly alkaline oil. Again the average benefit was well over 50%. In this case the service ranged from an oil field drill rig powerplant to a marine propulsion unit. Fuel sulfur content ranged from 0.35 to 1.2%, except that one engine ran on 0.15% sulfur fuel with the heavy-duty oil but on 0.60% sulfur fuel with highly alkaline oil.

Low-temperature corrosive wear is also reduced when oil of high detergency is substituted for one of low detergency, according to Jackson. He found this to be true in some laboratory tests he conducted with a Cooperative Oil Test engine and in winter passenger-car-to-and-from-work driving in Philadelphia using the radioactive tracer technique.

This improvement, which he considers to be due solely to the better corrosion protection ability of the oil of higher detergency, occurs only when engine temperatures are low (Fig. 6). When he raised the jacket temperature by using a higher temperature thermostat, winter front, and by increasing the average trip length, these differences disappeared, as shown in Fig. 7.

In general, these tests showed that higher wear was usually encountered during the coldest periods of operation, and the absolute wear differences between the oils were variable, depending on engine design, trip length, mechanical condition of the car, thermostat settings, driving habits, and so on.

Heavy-duty oil was compared with a nonadditive oil in a series of tests run by Palmer. His tests were designed to represent typical passenger-car operation. Fifteen cars covered an average of 14,000 miles each in 15 months. He concluded that the use of a heavy-duty crankcase oil in the MIL-O-2104 quality

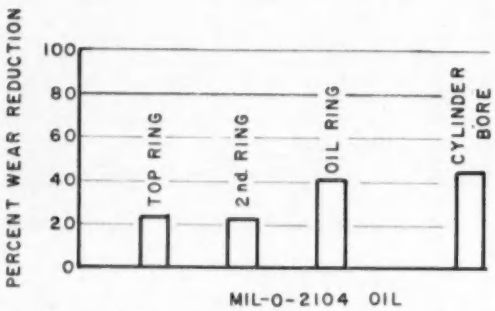


Fig. 8—Per cent reduction in piston-ring and cylinder-bore wear resulting from use of heavy-duty oil, as compared with base oil—1950 217 cu in. standard engine, approximately 14,000 miles, "home to work" service (from Palmer)

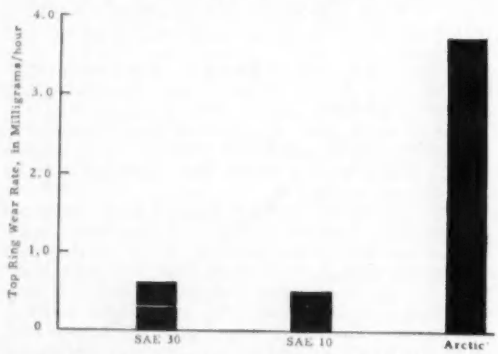


Fig. 9—Wear with arctic and conventional oils compared—Cooperative Oil Test engine, 2400 rpm, 280 F cylinder-wall temperature (from Jackson)

range compares as follows, on the average, with a nonadditive oil (Fig. 8):

1. Piston-ring wear is reduced by 37%.
2. Cylinder-bore wear is reduced by 42%.
3. Engine cleanliness is significantly improved. In terms of CRC merit ratings, the cleanliness is increased from 53 to 78.

One special wear problem discussed by Jackson concerned the arctic oils (MIL-O-10295), which have low viscosity and high V.I. The CRC arctic oil group had found that when these oils are used oil consumption and wear are abnormally high at normal engine temperatures. This wear problem was particularly severe in certain 2-stroke-cycle multicylinder diesel engines.

An examination of viscosity-temperature data for these oils showed that at 300 F or above, the viscosity of the arctic oil exceeds that of SAE 10. Since engine ring-belt temperatures above 300 F are normal, he suggested that the lubrication failures of the arctic oils might be caused by high volatility rather than low viscosity. For this reason he studied the effect of adding a heavy oil stock such as 15% bright stock to the oil in a COT engine, using the radioactive tracer technique. Fig. 9 shows that wear is about seven times higher with an arctic oil than with oils of conventional viscosity characteristics. Fig. 10 shows that the addition of 15% bright stock reduced the wear of the arctic oil.

George Round, Socony-Vacuum Oil Co., pointed out, in discussion, that reduced evaporation may be only one of the reasons why wear was less in these tests. He suggested that viscosity increase and better lubricating properties under boundary film conditions might be contributing factors.

In his tests, Jackson also found that the addition of antiscuff agents—chemical additives that react with the metal wearing surface at high temperatures to form low shear films—can also be quite effective, as shown by Fig. 11.

(Papers on which this abridgment is based are available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ a piece to members, 50¢ to nonmembers.)

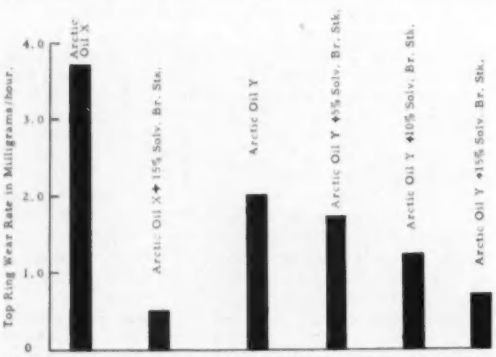

Top Ring Wear Rate in Milligrams/hour.
4.0
3.0
2.0
1.0
0
Arctic Oil X
Arctic Oil X + 15% Solv. Br. Stk.
Arctic Oil Y
Arctic Oil Y + 5% Solv. Br. Stk.
Arctic Oil Y + 10% Solv. Br. Stk.
Arctic Oil Y + 15% Solv. Br. Stk.

Fig. 10—Effect of bright stock on wear with arctic oils—Cooperative Oil Test engine, 2400 rpm, 280 F cylinder-wall temperature (from Jackson)

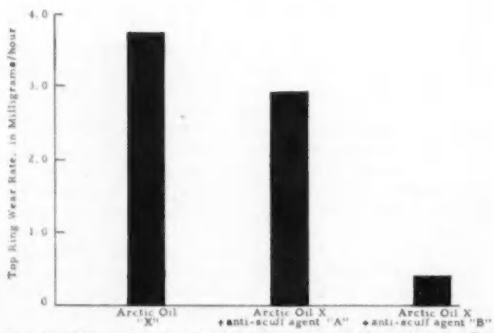


Fig. 11—Effect of antiscuff additives on wear with arctic oils—Cooperative Oil Test engine, 2400 rpm, 280 F cylinder-wall temperature (from Jackson)

Common-Carrier Operators Face Five Tough Problems

W. P. Davis, Vice-President, Associated Transport, Inc.

Excerpts from paper, "Common-Carrier Intercity Vehicle Design Requirements" presented at SAE National West Coast Meeting, San Francisco, Aug. 12, 1952.

THE common-carrier intercity trucking industry is beset with problems broad in scope and challenging in nature. Five noteworthy ones are:

- Size and weight regulations set up by the 48 states and the District of Columbia . . . most of which are different from each other.
- Lack of sufficient cubic capacity in tractor and semi-trailer combinations.
- Vehicles that weigh too much.
- Maintaining equipment at low cost.
- Need to improve features affecting safety.

What measures can and should be taken to solve these problems? Let us see . . .

● Size and Weight Restrictions

One of the greatest problems facing operators today is the size and weight regulations set up by the 48 states and the District of Columbia—the vast majority of which are different from each other. The only requirement that is somewhat consistent is overall height. Yet bridges and underpasses in some states are so low and arched in such a manner that roofs are sometimes torn off equipment built to specified state limits!

To illustrate the problems encountered with the various state size and weight regulations, let's assume a common-carrier truck is to operate between Boston, Mass. and Nashville, Tenn. Table 1 shows what operators would be up against.

Problems such as this one must be solved. State highway officials, truck and trailer engineers, and fleet operators ought to get together and agree on certain general principles.

The first thing that should be settled is the matter of concentration of weight. Weight of loads should be spread over a greater distance and the number of axles carrying loads increased. The American Association of State Highway Officials has issued certain recommendations on vehicle lengths and bridge formulas. They should be adopted in those states which have more restrictive laws.

● More Cubic Capacity

More and more articles of lighter weight are being shipped in common carriers today. Generally speaking, then, loads of miscellaneous commodities are lighter and more bulky. In view of these circumstances, it's vitally important to increase cubic capacity of these vehicles.

There is considerable wasted space in the various makes of trucks and truck-tractors. Examples of this are the spaces between radiator cores and radiator grilles and between radiator grilles and front bumpers. Experience shows that tractors can be designed to eliminate this wasted space . . . and without impairing driver comfort and accessibility. A good rule to follow would be to keep the front-of-bumper to back-of-cab dimension in conventional type tractors under 102 in.

Obtaining increased cubic capacity at the present time is also limited by the variation in unladen fifth wheel height of tractors. To comply with maximum overall height regulations, trailer builders now make standard trailers to fit the highest fifth wheel height. If trailer manufacturers are to supply the much needed extra capacity in their units, tractor manufacturers must design their vehicles so that the unladen fifth wheel height is not over 48 in.

Distance from the top of tires to the floor of trailers should be kept to a minimum, too. This can be done by improving the placement or type of springs.

What's more, since bridge formulas are figured to the nearest foot, a difference of 1 in. in vehicle wheelbase can result in a gain or loss of as much as 850 lb of payload. Trailer axles should be located at the rear of a trailer body so that the tires are in line with the rearmost portion of the trailer body. The controlling factor at the front end of a tractor should be the front-of-bumper to centerline-of-

front-axle dimension. This distance must be rigidly controlled if the maximum practicable wheelbase is to be obtained.

● Less Dead Weight

Heavy commodities are also carried by motor carriers today. But if this freight is to continue to move via truck instead of by rail, then motor carriers must be placed in a position that will enable them to haul weight in payload rather than in dead weight. In many Eastern states, unladen equipment weighs as much as the payload a carrier is permitted to haul.

To correct this situation, lighter weight materials must be substituted wherever possible in the component parts of vehicles. The trailer industry has already done considerable work along these lines . . . but much remains to be done. Truck-tractor manufacturers have not done too much to date along practical weight-saving lines. They should try to save weight everywhere. A reasonable goal at which to shoot would be a tractor, semi-trailer weight of one-third the gross load.

● Simpler Maintenance

Increasing labor costs call for getting greater and greater miles—at lower cost—out of our units. Surely, the problem of increased maintenance cost and "down time" can be improved considerably by elimination of some lubrication points. The replacement of greased lubricated parts in tractor and trailer rear-axle assemblies with rubber-bushing counterparts is a good example of what can be done. Another is the elimination of lubrication points on brake camshafts by using prepacked, sealed bearings.

Reduction in the number of items that need manual adjustment would help, too. So would reductions in the amount of time needed to remove and reinstall certain parts and components.

As for standardization, let's standardize the electrical system voltage for all intercity equipment—and 12 v, please! Let's adopt a standard color system for wiring trailers. Let's wire trailers from the exterior of the body so that equipment does not have to be unloaded, or cargo shifted, to correct faulty wiring.

In short, joint engineering studies aimed at simplifying repairs in fleet shops would undoubtedly pay off not only in fewer maintenance operations but also in increased mileage between these maintenance operations.

● Safety Promoters

The high cost of today's motor vehicles makes it economically desirable to keep them "working" as much of the time as possible. This means shifting drivers around . . . and records show that this practice may lead to accidents. Drivers get themselves into trouble due to the different locations and operating characteristics of the instruments and controls in various trucks. Establishment of a standard instrument panel, therefore, would be a definite contribution to safety. And while we're at it, let's leave all fancy instruments and ornamental gadgets off this panel.

If a standard gear shift pattern could be worked out, without retarding transmission improvements, it would be helpful, too. And if the tinted, glare-proof glass being built into automobiles for the casual driver's pleasure is safe and practical, then why not provide it for the professional driver?

It would also seem advisable to change the present bumper location on truck-tractors. Lowering them to a height comparable to that of automobile bumpers would be a good idea. Then, in the case of a minor traffic accident, the tractor would strike the car bumper instead of the rear trunk lid or the passengers in the car.

For a number of years, the trucking industry has sought these improvements. Surely the time has come when yesterday's desires should be today's realities—and today's needs tomorrow's achievements.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Table 1—Vehicle Size and Weight Limits for Common-Carriers Operating between Massachusetts and Tennessee

State	Height Ft-in.	Length		Axle Load		Maximum Gross Weight			Bridge Formula
						Tractor Semitrailer			
		Tractor Semi-Trailer	Combination	Single Axle	Tandem Axle 4 Ft Apart	Single Axle	Tandem	Combination	
Mass.	N.S.	45	N.P.	22,400	36,000	50,000	50,000	N.P.	No
R. I.	12-6	50	50	22,400	32,000	50,000	50,000	88,000	No
Conn.	12-6	45	N.P.	22,400	36,000	50,000	50,000	N.P.	No
N. Y.	13-0	50	50	22,400	36,000	53,000	63,000	63,000	Yes
N. J.	13-6	45	50	22,400	32,000	53,800	60,000	60,000	No
Penna.	12-6	45	50	20,000	36,000	45,000	45,000	45,000	No
Del.	12-6	50	60	20,000	36,000	49,000	60,000	60,000	Yes
Md.	12-6	55	55	22,400	40,000	53,800	65,000	65,000	Yes
D. C.	12-6	50	50	22,000	38,000	53,000	65,400	65,400	Yes
Virginia	12-6	45	45	18,000	36,000	40,000	50,000	50,000	No
Tenn.	12-6	45	45	18,000	36,000	42,000	42,000	42,000	Yes

N.P.—Not Permitted N.S.—Not Specified

New Equipment Maps Jet-Engine Stall Areas

MODERN jet engines generally employ axial flow compressors. These engines are rapidly approaching design objectives, but they still have one undesirable trait—compressor stall.

Existence of a stall area usually lengthens the time required to accelerate an engine from idle to maximum speed. And if fuel flow is not reduced the instant stall occurs, dangerously high burner temperatures will result.

An automatic stall detector would be most desirable, but none has yet been developed. However, instrumentation for locating the boundaries of compressor stall has recently been developed.

Both the instrumentation itself and the way it is used to map out stall areas are described in this article.

W. J. Kunz, Jr., Bendix Products Div., Bendix Aviation Corp.

Excerpts from paper, "A New Technique for Investigating Jet Engine Compressor Stall and Other Transient Characteristics" presented at SAE National Aeronautic Meeting, New York, on April 23, 1952.

FOR the first time, equipment has been developed that can rapidly and accurately determine the location of stall areas of jet-engine axial compressors. It consists of a very accurate, medium-fast recording system that presents data directly on x and y coordinates and a fuel control that feeds information to the recording system.

Plotting Boards

Most electronic recording devices today present one or more channels of information with respect to a time base. They usually have a small scale deflection, and some require a photographic process to develop film after recording.

However, our needs called for an instrument that could record two independent variables simultaneously. This brought to mind the plotting boards used for tracing the instantaneous positions of ships. Although slow in response time, they represented the type of machine needed.

Initially, consideration was given to designing a high-speed plotter. However, a commercial unit became available which pretty much filled the bill . . . and several were purchased.

Each unit can draw a 30 × 30 in. graph. Fig. 1 shows one of the boards currently being used. This particular unit has two pens for presenting data on X–Y and X′–Y′ axes simultaneously.

Two electrical servo-mechanisms direct the X and Y travel of a pen. The pen position on either axis is proportional to the magnitude of the input voltage applied to that axis.

Fig. 2 shows a block diagram of a plotting board as set up to record engine speed and fuel flow. In addition to the measurements shown in this diagram, other equipment has been designed to permit picking up and recording engine speed, fuel flow, engine temperature, gas and fluid pressure, mechanical motion of levers, time, and a-c voltage.

This plotting board system is a most efficient means of recording data on two variables. It permits one to see immediately the effect of various control adjustments.

Brains Behind Plotting Pens

A fuel control system feeds information to the plotting board pens. It utilizes an all-speed isochronous governor for steady-state operation of the engine and a system of speed-scheduled fuel flow for acceleration control. The only engine connections required for operation of this control are a tachometer speed pick-up and fuel lines to the nozzle assembly.

One of the most important elements of this control is the main fuel valve assembly. This unit consists of an electric motor-driven valve which

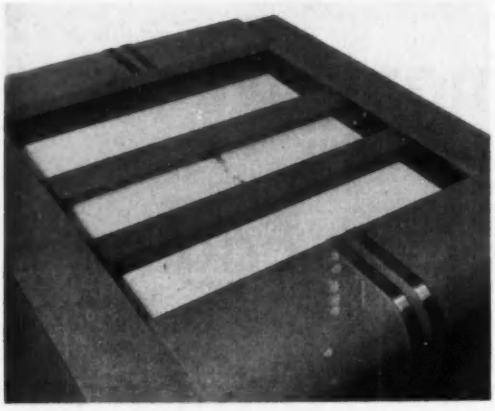


Fig. 1—This two-pen plotting board records information fed to it directly on x and y coordinates

operates freely between two adjustable mechanical limit stops. Fuel pressure across this valve is maintained at a constant value. Consequently, engine fuel flow is directly proportional to the metering valve area. One limit stop controls the minimum fuel flow to the engine; the other controls the maximum permissible valve opening.

To govern the engine speed during steady-state conditions, it is only necessary to apply a suitable electrical control signal to the fuel valve motor. Whenever the engine is below the selected speed, the fuel valve operates in an opening direction until it contacts the acceleration limit stop. Thus, the instantaneous fuel supplied to the engine during acceleration is controlled by positioning the limit stop. With this system, there is complete isolation between the governor and acceleration elements.

To achieve maximum acceleration performance from an engine, it is necessary to inject the exact and proper amount of fuel at each instantaneous value of engine speed. The control of acceleration fuel in a smooth, continuous manner is most ideal. However, it is practically impossible to achieve such scheduling and still permit accurate curve adjustment. With the control system used, the engine speed range has been divided into fifty increments or, in other words, fuel feed is adjustable from zero to maximum value every 2% of engine speed.

Control of the individual steps is accomplished with two positional electronic servos. The first servo rotates a fifty-contact switch to an angular position corresponding to the instantaneous value of engine speed. Thus, for a given engine speed, a known contact can be selected. An electrical potentiometer connected to each contact determines the desired opening of the fuel valve. The second servo then positions the valve limit stop to the value required by the potentiometer.

Overall operation of the control was materially improved by adding a temperature controller unit to the fuel valve and temporarily disconnecting the scheduling mechanism. When in operation, the temperature control supplies the correct amount of fuel to accelerate the engine at the tailpipe or burner temperature selected by the operator. By reviewing the fuel flow values obtained with the temperature unit, an initial setting for the schedule control can be determined. The temperature unit also permits rapid determination of the surge or compressor stall region of an engine.

Operation characteristics of a new engine are determined with the aid of both the plotting board and the universal test control. The fuel control is connected to the engine and the maximum and minimum speed adjustments are made. Usually tailpipe thermocouples are connected to the temperature controller and the plotting board arranged to record fuel flow versus engine speed and compressor discharge pressure versus engine speed. The compressor discharge pressure measurement indicates the point at which compressor stall occurs.

Stall Areas Pin Pointed

Approximately seven engine accelerations are required to define the shape and location of the compressor stall area. The tests are divided into two parts:

- Determination of entering or low rpm points of the stall area.
- Defining the high rpm limits or trailing boundaries of compressor stall.

With the equipment setup as previously described, these steps are taken:

1. The engine is brought up to operational speed. The scheduling portion of the universal test control is removed from the circuit and the temperature controlling amplifier connected to the main fuel valve. The temperature controller is adjusted to some value just above the required-to-run temperature of the engine, for example, 1250 F.

2. The engine is then accelerated from idle to maximum speed. One pen on the plotting board records the fuel being supplied to the engine to maintain the 1250 F temperature. The second pen plots the compressor discharge pressure with respect to engine speed. Curve AB, in Fig. 3, shows typical information obtained in this test run. Usually on a low-temperature acceleration such as 1250 F, no stall is encountered.

3. The engine is returned to idle speed and the temperature setting of the controller increased to 1350 F. The engine is again accelerated to maximum speed and recordings are made on the plotting board. If stall is encountered, the exact point of entry can be noted by the sharp decrease in compressor pressure, as illustrated by curve CD, in Fig. 3.

The exact fuel flow and engine speed at which stall occurred can also be determined by referring to the plotting board graphic information. The fuel flow value thus derived is used as one point for defining the complete shape of the stall area.

4. Similar engine accelerations are repeated, with the temperature setting of the controller raised in 100 F increments, until the engine is operating at its maximum safe temperature. The fuel flow values required to cause compressor stall are noted. They form the pattern shown in Fig. 3 by lines EF, GH, and IJ. Five accelerations usually suffice for

determining this part of the stall area.

To complete the second phase of the stall determination, it is necessary to define the high rpm limits of the area. This is usually done as follows:

1. The temperature amplifier is set to the maximum value permissible for engine operation, for example, 1650 F. Engine speed is adjusted to a speed which is slightly higher than the previously determined speed information on stall, and the engine is then accelerated from that speed point to maximum speed. During acceleration, fuel fed to the engine is increased rapidly to bring the engine up to the temperature demanded by the temperature controller. Stall may be encountered at some point on the fuel flow curve, as illustrated by curve KL, in Fig. 4.

2. The same procedure is repeated with one or two more accelerations. Each time the speed at which acceleration starts is increased. This procedure will net a series of stall points, as shown by lines KL and MN, in Fig. 4.

Two engine accelerations are normally used to determine the high rpm boundary limits because stall effects in this region are extremely violent and an engine could sustain structural damage.

The seven engine accelerations described provide a reasonably good definition of the entire stall area shape and location. (See Fig. 5.) They also provide approximate fuel flow information for operating the engine at maximum temperature.

Of course, the stall area now defined is valid only for the environmental conditions under which the test engine was operated. It is well known that changes in ambient temperature and other engine conditions will cause the stall area to shift position. Fortunately, however, other test programs with the engine operating under various ambient conditions can be carried out easily and quickly.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

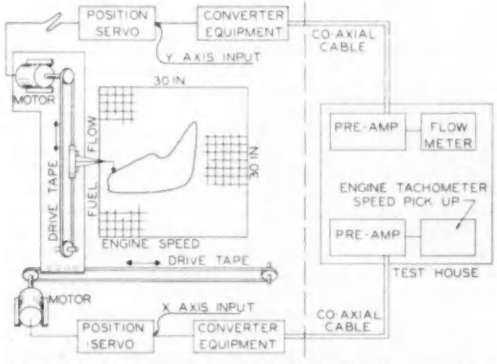


Fig. 2—This block diagram shows a plotting board system arranged to record fuel flow versus engine speed

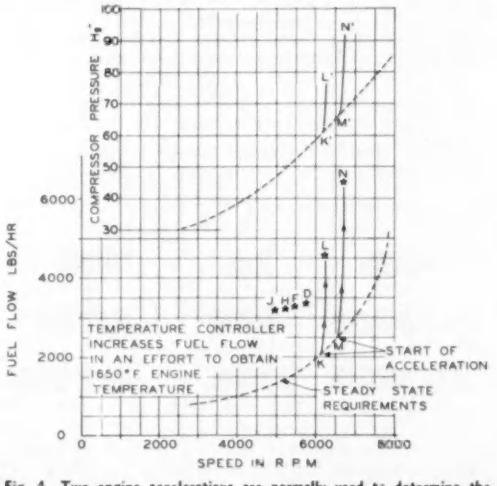

COMPRESSOR PRESSURE Hp
FUEL FLOW LBS/HR
SPEED IN R P M
TEMPERATURE CONTROLLER INCREASES FUEL FLOW IN AN EFFORT TO OBTAIN 1650°F ENGINE TEMPERATURE
START OF ACCELERATION
STEADY STATE REQUIREMENTS

Fig. 4—Two engine accelerations are normally used to determine the high rpm limits or trailing boundaries of compressor stall

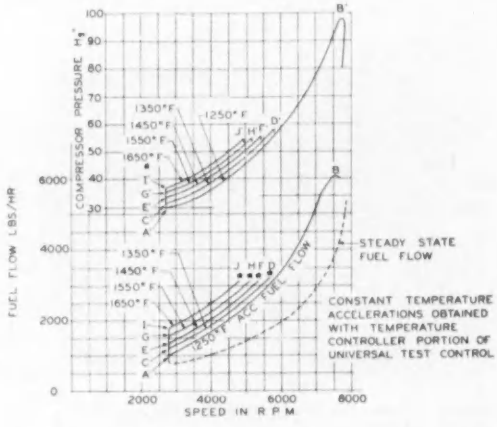


Fig. 3—Five engine accelerations usually are enough to define the entering or low rpm points of a compressor stall area

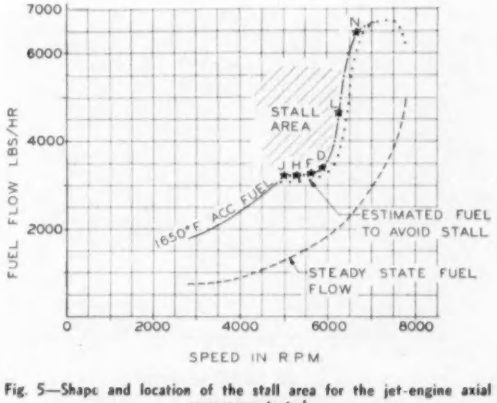


Fig. 5—Shape and location of the stall area for the jet-engine axial compressor tested

Combustion–Chamber

THIS paper is not an attempt to set forth bold theories on the mechanics of combustion-chamber deposits and their effect on engine thermodynamic conversions. Instead, it is a recapitulation of our experimentation to date, accompanied by our conclusions, some of which are admittedly probationary. Our investigation was mainly concerned with the effects of deposits on knock-unlimited power; that is, power loss which occurs at optimum spark settings with fuel that is knock-free at those settings. Therefore, the effects of deposits on engine octane requirements are not considered.

Combustion-chamber deposits are mainly lead compounds from the tetraethyl lead of gasoline, and are attached to the cast-iron combustion chamber and aluminum or cast-iron pistons by means of resins derived from the gasoline in combination with the lubricating oil in some complicated series of chemical reactions which the writers do not pretend to understand, let alone explain. That these resins exist and act as a primary binder for the lead deposits seems well established by existing data. Therefore, some effect upon the accumulation of deposits can be obtained by varying the composition of the gasoline and oil, in so far as these compositions tend to add to or detract from the resin binders or the lead components of the combustion products. Further, it would seem within the realm of possibility to prepare a combination of commercial gasoline and oil which would so react that no resin binder would be formed, thus avoiding the retention of offending lead in the combustion chambers. Obviously, if this much of the theory is to hold, some simple experimentation with varying amounts of tel in the gasoline, as well as some changes in oil composition, should show positive results.

Fig. 1 shows the effects of increasing tel content on deposit accumulation after 37 hr and at equilibrium. Fig. 2 shows the effects of increasing tel concentration on power loss at four intervals, and at equilibrium. The combination of these two figures presents us with the inescapable conclusion that both power loss and deposit weight increase with in-

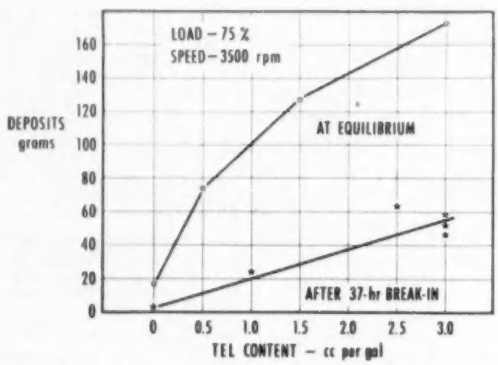


Fig. 1—Effect of lead concentration on deposit accumulation

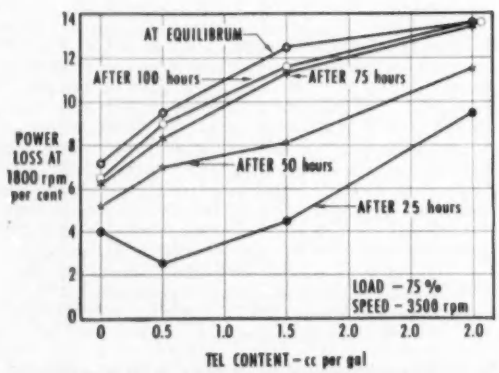


Fig. 2—Effect of lead concentration on power loss

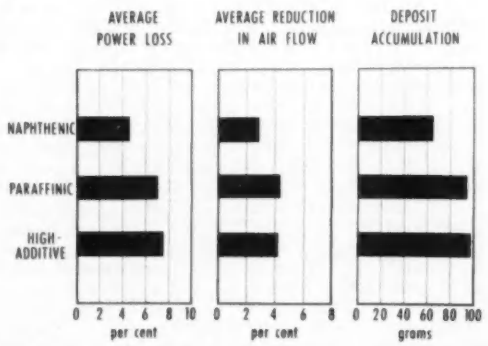


Fig. 3—Effects of deposits with three types of oil

Deposits and Power Loss

A. E. Cleveland and O. Enoch, Ford Motor Co.

Excerpts from paper, "Combustion-Chamber Deposits and Their Relationship to Power Loss," presented at the SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 4, 1952.

creasing tel content in gasoline, and that this is true whether we consider initial accumulation or final accumulation.

We emphasize the latter point because it has been suggested that only the initial accumulations of deposits were a function of tel content, and that the subsequent stabilization point was the same with 1 cc per gal as it was with 3 cc per gal, except that it took longer to reach equilibrium with 1 cc per gal. Our data indicate that the more lead there is in the gasoline, the more deposits accumulate and the greater is the power loss at any time during similar operating schedules on similar engines.

Now for a quick look at the effects of motor oils. In Fig. 3, a non-additive naphthenic, a non-additive paraffinic, and a high-additive paraffinic are compared for their effects on deposit accumulation, airflow, and power. We will not attempt to draw conclusions from these comparisons, beyond the obvious one that there *is* a difference due to oils, and that deposit accumulation and power loss are significantly less with the naphthenic oil than with either of the paraffinic oils of differing anti-oxidant and detergent levels.

Fig. 4 gives us a close look at combustion-chamber deposits in what is probably their worst power loss condition, and provides an interesting background for further theoretical speculation before we introduce additional test data.

Trying to visualize what happens to cause such an accumulation of deposits leads us to imagining lead salts drifting about in the combustion chamber like snowflakes in the atmosphere. Some of these flakes are blown away; some fall upon a warmer surface to melt, change form, and disappear; and some pile up into drifts, remaining until they are scraped away by some consciously directed force. Fortunately, in a combustion chamber, the percentage of these flakes that is harmlessly blown away is probably far greater than in the snowflake analogy. This would seem only logical, since the velocity of the air acting to blow them away is relatively much greater in a combustion chamber. Besides, a quick and easy calculation shows that only about one-half

Fig. 4—Deposits at probably their worst power loss condition—formed after 223 hr at 3500 rpm and 75% load—tel content was 3 cc per gal

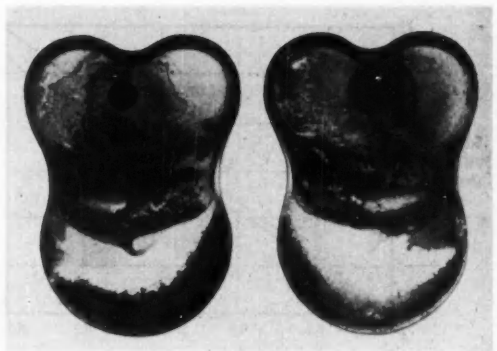


Fig. 5—Deposits that resemble drifted snow—formed after 35 hr at 3500 rpm and 75% load—tel content was 3 cc per gal

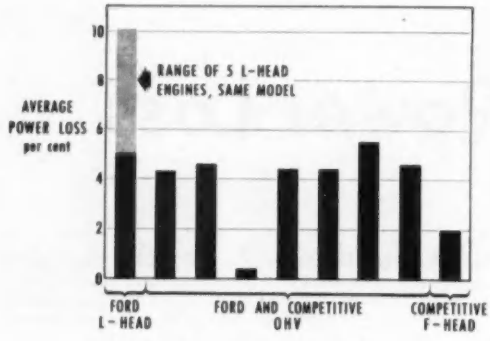


Fig. 6—Power loss caused by deposits

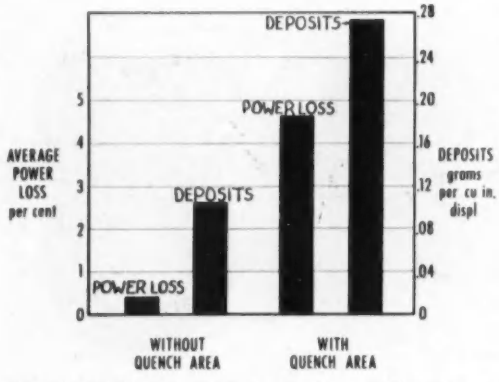


Fig. 7—Relationship of quench area to deposit accumulation and power loss

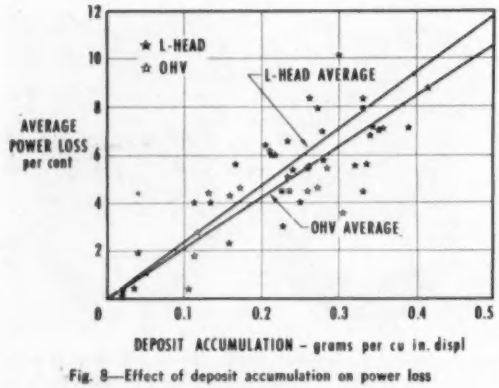


Fig. 8—Effect of deposit accumulation on power loss

of one per cent of the amount of lead in the gasoline remains in the combustion chamber.

Areas of the combustion chamber where changes in air velocity are greatest show higher concentrations of deposits than areas of little or no change in velocity. Likewise, engine types in which the vector change in air velocity is low show smaller amounts of deposit accumulation. This change in velocity with respect to time (dv/dt) is, of course, acceleration, which, when applied to the mass of a lead salt particle, becomes a force acting through a distance, or work. A change in velocity, therefore, means a change in capacity to do work, with consequent rearrangement of the particle-carrying capacity of the gas.

Therefore, as a snow fence precipitates a snowdrift by upsetting the air currents at that point, so a quench area may precipitate lead salts from the air stream. These particles are then caught by the resin on the combustion-chamber walls, like flies on flypaper, where they increase in density and/or thickness, depending on the temperature-pressure conditions. Bear in mind that, in addition to cooling the charge, a quench section causes intake and compression as well as combustion turbulence.

Fig. 5 shows this condition and is well suited to the analogy, since the lead salts most certainly resemble drifted snow. There is obviously much more to the story than this, however. A few of the questions still unanswered are: Why is the section around the exhaust valve clean? What forces cause the deposits to scale and break off? At what time during the cycle does the formation occur? There are many more questions than answers, which you will recognize as the usual state of affairs in investigations of this kind. Consequently, we are not trying to sell a theory, but rather to use it as a convenient backdrop upon which to arrange and classify data. With this in mind, let us leave the backdrop and return to the data.

Fig. 6 shows that power loss, in both Ford and competitive ohv engines, is generally less than power loss among a number of L-head engines run on the same schedule. One explanation for this lies in the less turbulent flow pattern of the ohv engine, as compared to that of the L-head engine. This theory is further supported by the fact that the engine showing the least power loss is also the engine which has the most direct flow of gases through the combustion chamber, lacking even the conventional quench area.

Fig. 7 shows a comparison between this low power-loss engine and a more conventional ohv engine. Here you can see more clearly that the relationship btween power loss and deposit accumulation remains valid.

The shotgun pattern of Fig. 8 is the result of an attempt to discover from the data if the power loss per gram of deposits is greater in an L-head engine than it is in an ohv engine. It so happens that, by carefully weighing the points to arrive at an average slope, the effect of a gram of deposits on power appears to be slightly greater in an L-head engine. This, as you can see, is not very clear-cut, and will not support a great weight of theory. However, the very inconsistency of the results is in itself significant, for it shows that grams of deposit do not individually possess a uniform power-loss value, al-

though collectively they seem to reach a uniform average.

Figs. 9 and 10 show the distribution of deposits by weight, and power loss as a function of location within the combustion chamber in an L-head engine. Looking first at Fig. 9, you will observe that the greatest concentration of deposits is in the quench area, followed in decreasing order by the piston top, the throat area, and the cylinder block and valve chamber.

Fig. 10 shows the same areas, but rates them on the basis of their area-proportional contribution to the power recovery of the engine, as they are differentially cleaned. Here, again, the quench area is found to contribute most to the power loss, but the piston tops, which have the second largest concentration of deposits, are next to the last in area-proportional effect on power recovery. The throat area and the cylinder block and chamber follow in the same respective order of power loss as they would in order of deposit concentration, but the spread of the data is much greater. This, in view of our ability to measure power with great accuracy, leads us to suspect the existence of some real variables hiding from the rigid controls of this test. The small contribution of the piston top area to power recovery can be explained by any of the intake charge heat theories, since piston top temperatures do not appear to be greatly affected by the accumulation of deposits. The relatively large contribution of the quench area to power loss is probably due to the combination of large deposit concentration and the scrubbing effect of the intake charge. The variability of power loss in the throat area correlates, to some extent, with the variable pattern of deposit accumulation in the same area. However, this variability will bear, and is receiving, further investigation.

Before we had completed the series of tests we are now about to analyze, we had a good, airtight theory that ohv engines were less susceptible to deposit power loss than L-head engines because of their lower surface/volume ratio. This would seem logical because the lower surface/volume ratio provides a smaller area for deposit formation; consequently, a smaller heat-retaining capacity during combustion, with less reflux-heating of the incoming charge. This theory is only partly right, however, as you will see from the subsequent data.

Fig. 11 shows the relationship between surface/volume ratio and deposit weight per cubic inch of displacement in eight different designs of current ohv engines. The surface/volume ratio is the total area exposed to the charge, divided by the volume of the combustion chamber. The deposit weight is presented as a weight per unit displacement, to obtain a uniform basis for comparison of engines with different breathing capacities. The horizontal axis has no special significance except as a means of arranging the data on the eight engines in such a way that, if the top line of surface per unit volume were parallel to the deposit-weight line, we could see that deposit accumulation followed the theory of increasing as a function of surface/volume ratio. You can see that the general tendency is there, but that least two of the engines are badly out of line.

Fig. 12 shows a similar relationship between sur-

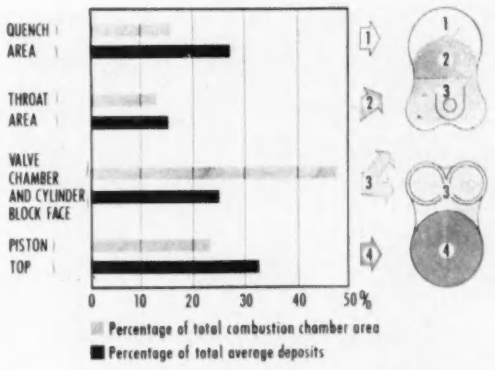


Fig. 9—Distribution of combustion-chamber deposits

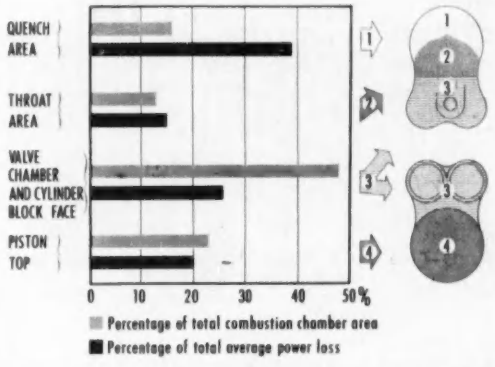


Fig. 10—Power loss distribution as determined by location of combustion-chamber deposits

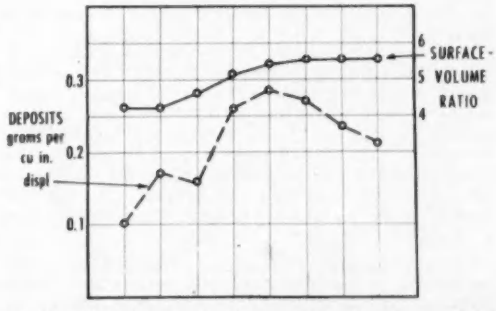


Fig. 11—Relationship of surface/volume ratio to deposit accumulation

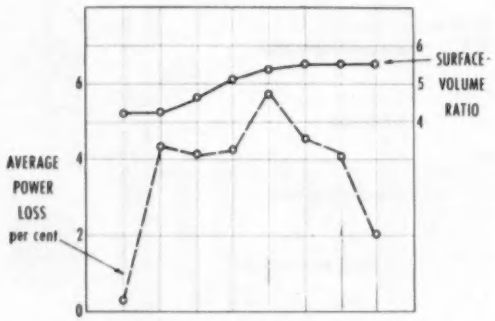


Fig. 12—Relationship of surface/volume ratio to power loss

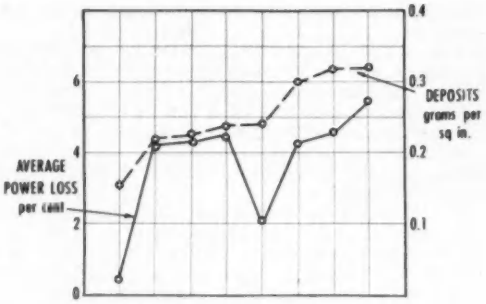


Fig. 13—Effect of deposit concentration on power loss

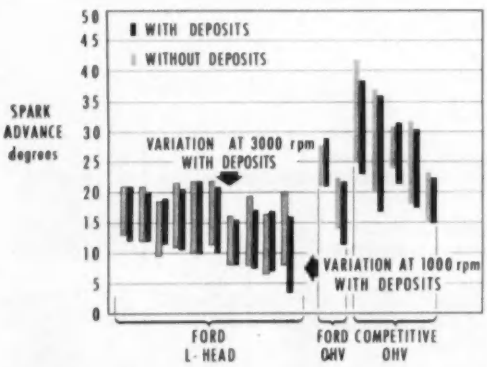


Fig. 14—Decrease in minimum spark advance for best engine torque caused by deposits—1000-3000 rpm

face/volume ratio and power loss for the same eight engines. Here the correlation with the surface/volume theory is even less apparent, although the trend still exists.

Fig. 13 presents these same eight engines in a comparison between power loss and deposit weight per unit of surface, or deposit concentration. Although not a perfect match, this comparison appears to fit the data better than the previous area-volume comparison, so let us examine its possibilities.

Returning once more to the snowflake analogy, you will recall how we theorized that large and frequent changes in air velocity would cause precipitation of lead salts, just as a snow fence starts a snowdrift, and that there were probably fewer snow fences intrinsic in ohv engine design than in L-head design. Also, that the ohv designs having the freest flow through the combustion chamber seemed to have the least deposit accumulation and smallest power loss.[1] If this is assumed to be true there immediately arises the question of the connection between deposit accumulation and power loss. For the answer to this question, we have chosen to link our theory and data with some excellent work reported by Dumont.[1]

Dumont showed the increased heat-insulating effect of deposit formations. It seems to us, however, to be not so much a question of the insulating effect of the deposit mass, but a question of its heat coefficient, or its ability to store heat. The deposit mass is a storage bank for thermal units or, if you like to think in terms of electrical analogies, a kind of heat capacitor. The deposit mass absorbs heat during combustion, stores it up, and returns it to the gases during the cold part of the cycle on the intake stroke.

In an electrical capacitor, the larger its capacity, the more energy it stores from a given voltage. Thus, with the heat capacitor, the greater its mass and density, the more heat it absorbs from a given peak temperature. In this case, we are not so much concerned with the heat robbed from combustion as we are with the heat returned to the intake, although, in terms of the theoretical cycle, the area of useful work is made smaller in both cases. Now, before our theory picks up too much momentum and starts free-wheeling, let us introduce some more data.

One of the few ways an engine can communicate its combustion requirements to the operator is by its power response to spark advance. Fig. 14 shows the maximum-power spark-advance requirements of a number of L-head and ohv engines. Those shown in the grouping at the left are L-head Ford V-8 engines, of 239 cu in. displacement. Those in the random grouping at the right are various models of Ford and competitive ohv engines. There are dark and light bars for each engine, the dark bar representing the optimum spark-advance requirements with deposits, and the light bar representing the optimum spark requirements with deposits removed. The lengths of the bars represent the spark-advance spread between 1000 rpm (the lower limit) and 3000 rpm (the upper limit). The shaded areas in the left grouping show the spread of requirements (with deposits) at the 1000- and 3000-rpm points for engines of the same model on similar schedules.

[1] See SAE Quarterly Transactions, Vol. 5, October, 1951, pp. 565-576: "Possible Mechanisms by which Combustion-Chamber Deposits Accumulate and Influence Knock," by L. F. Dumont.

Some interesting conclusions can be supported by these data. First, we see that ohv engines tend to require greater spark advance for maximum power than do L-head engines, which means that the mixture must be ignited sooner in an ohv engine if it is to develop its effective pressures at the optimum piston location. Inasmuch as the piston-crankshaft relationship in ohv engines does not differ materially from that of their L-head counterparts, it is quite safe to reason that the mixture burns more slowly in an ohv combustion chamber than in an L-head chamber. Or, in more general terms, earlier optimum-power spark events mean slower-burning mixtures. This is not a new discovery, but it is interesting because, among other factors, it points to the lower turbulence of the ohv combustion chamber, and indicates that this lower turbulence, or lower change of fluid velocities, may be partly responsible for lower amounts of deposit.

Another conclusion might be drawn from the grouping on the left side of the figure, to the effect that reproducibility of optimum spark advance between similar engines is less than the variation for the same engine with and without deposits. This is another way of saying that other factors within the engine affect the rate of mixture burning more than does the presence or absence of deposits. This is not too surprising, however, because the presence of deposits might well be presumed to introduce several factors which act in opposite directions in their effects on the rate of flame propagation or pressure buildup.

If our heat-capacitor deposit layer imparts heat energy to the intake gases, as we have assumed, then it increases their turbulence and, consequently, their rate of burning (decreased spark advance). But, at the same time, it decreases the density of the charge, forces the molecules farther apart, and thereby slows down the rate of burning (increased spark advance). The presence of deposits, by virtue of their physical volume, of course, decreases the clearance volume and increases the compression ratio slightly. This should increase the compression pressures and increase the rate of burning (decreased spark advance), but, because of the rough surface provided by the deposit layer, scavenging of the exhaust gases is made more difficult, and the dilution of the intake gases thus promoted forces the active molecules of the gas farther apart, slowing the burning rate (increased spark advance). As you can see, the data split greater and lesser spark advance with deposits about half and half among all the types of engines, which, considering the number of theoretical variables, is not a bad probability.

In conclusion, you might like to take a look at some solutions that didn't work. Fig. 15 shows some serrated combustion chambers that were made on the theory that we might mechanically or thermally crack the deposits out of the combustion chamber and send them on their way.

Fig. 16 shows some encouraging results we had from the waffle-grid design, and on the basis of which an engine was made up, incorporating this design in all chambers. Before any designers of combustion chambers conclude that we have lost our minds, let us remind them that we were working with one variable only, the weights of deposits. All normal combustion-chamber design considerations

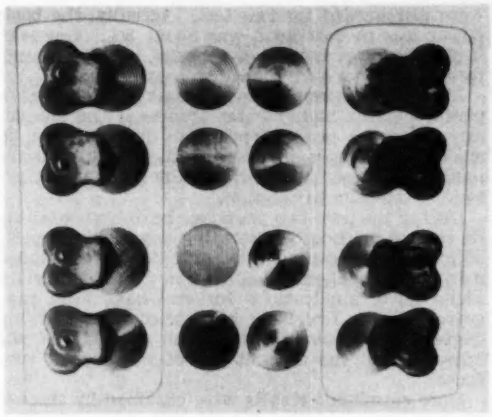


Fig. 15—Serrated combustion chambers

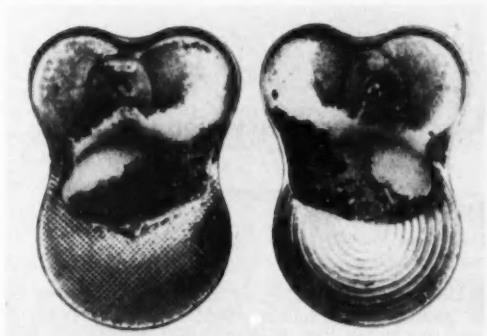


Fig. 16—Waffle-grid design—after 35-hr operation at 75% load and 3500 rpm—tel content was 3 cc per gal

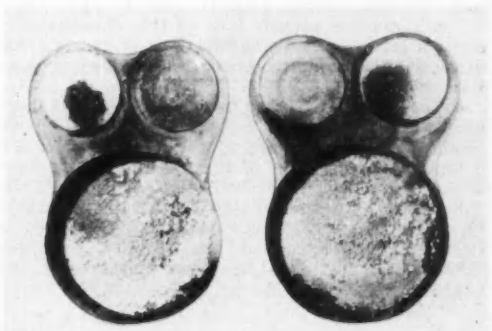


Fig. 17—Bubbles formed when aluminum pistons are used—after 61 hr at 100% load and 2000 rpm—tel content was 3 cc per gal

were disregarded for this test. Actually, the basic power loss in this head was about 3%. However, it did show a reduction of deposits, but not enough to warrant more than academic attention.

Aluminum pistons cause reactions which make the piston deposits highly water-absorbent and eventually cause the piston deposits to dissolve. Fig. 17 shows the bubbles which form as a result of this reaction. These bubbles eventually break up, carrying the deposits in solution.

During the past two years, we have been working on several methods of removing deposits as a periodic service operation. These studies have included many types of chemical and organic blast materials. Many novel applications for rice have been suggested, and a few have been tried, with varying degrees of success, depending on the skill of the operator and the accessibility of the deposit surfaces.

More consistent results were obtained by the use of plain water, sprayed directly into the combustion chamber on the intake stroke. There were, unfortunately, no compromises with this method. The water had to be sprayed in at the right time, in the right place, and in a stream as from a garden hose. Apparently it worked by thermal shock to blast particles from their "flypaper" resin base. When all of the factors for thermal shock were right, the combustion chambers were cleaned in about 75% of the tests. What happened in the other 25%, we are still trying to determine.

We hope that a satisfactory service cleaning method, making use of the best chemical cleaning materials and the easiest and most foolproof methods of application, can soon be announced. But, although service cleaning may be construed as a step forward in the practical solution of the problem, we feel that it is only a good crutch and we expect, through continued research, to find a way of making our engines less susceptible to deposit power loss, without sacrificing any of their efficiency or the practical elements inherent in their design. We are also encouraged by the current research of the oil and additive manufacturers, which leads us to believe that they will be able to come at least halfway by making fuel and fuel additives that are not so hard to remove from combustion chambers.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Excerpts from Discussion

Harold J. Gibson
Ethyl Corp.

OUR data[a] on the effect of tel concentration on deposit power loss in constant-speed and constant-load operation are in substantial agreement with the authors' Fig. 2, which shows power loss to be twice as great with 3 ml tel per gal as with clear gasoline. I wish to emphasize the fact that this effect of tel concentration applies only to operation in which speed and load are constant for substantial periods of time. Break-in running in which speed and load are increased stepwise but remain constant for considerable periods falls in this classification, as do a few specialized applications of gasoline engines, such as pumping, generating, and wind blowing.

Extensive study has led us to the belief that there are two major design factors that affect deposit power loss when engine operational variables are comparable. The first of these is the combustion-chamber area per cubic inch displacement. While the deposit weight per square inch combustion-chamber area varies somewhat among engines of comparable displacement per cylinder, the heat capacity concept indicates that the greater the chamber area deposit factor, the greater is the total

[a] See SAE Quarterly Transactions, Vol. 6, October, 1952, pp. 594-605: "Combustion-Chamber Deposition and Power Loss," by H. J. Gibson, C. A. Hall, and A. E. Huffman.

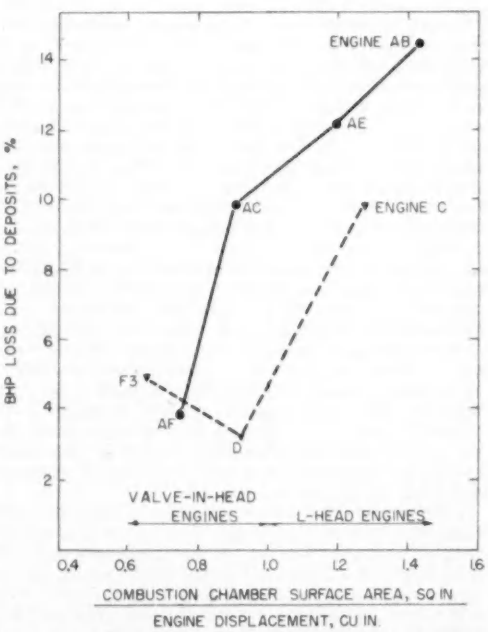


Fig. A—Effect of ratio of combustion-chamber surface area to engine displacement on deposit power loss

heat capacity of the deposits. Combustion-chamber area per cubic inch displacement should, therefore, be kept at the minimum value consistent with other design requirements. Fig. A illustrates this with data from two groups of engines. Each group was run on the same fuel and lubricant under similar speed and load conditions. It will be noted that in general the lower the area/displacement ratio, the lower the deposit power loss.

The low power loss of engine D, with a relatively high area/displacement ratio, is believed to be the result of the second of the two major design factors, that is, the location of the deposit-coated surfaces relative to the incoming charge.

The design of engine D is such that the incoming charge apparently contacts only a small, deposited-coated area, most of the scrubbing being against the clean cylinder walls. In this connection, it should be remembered that reduction in airflow, which causes about two-thirds of the power loss caused by deposits, results from the heating of the charge prior to the closing of the intake valve. Prevention of the scrubbing of the deposits by the incoming charge may, therefore, result in relatively low power loss, even though the chamber area is high.

We do not agree with the authors that their Fig. 14 proves that deposits have no average effect on ignition timing for maximum power. In every engine we have tested the advance for maximum power with deposits has been less than that for the clean engines. This even applies to those instances in which power with deposits was greater than in the clean engine.

New Harvester . . .

. . . cuts, cleans, and loads sugar cane into wagon in one operation. One machine with three men replaces 100 hand laborers and the end product is better.

BASED ON PAPER BY **B. C. Thomson** Thomson Machinery Co. Inc.

PRESSURE to mechanize the harvesting of sugar cane has been mounting wherever sugar is produced, due to the increasing shortage of labor and rise in wages which has not been offset by an increase in the price of sugar. In Louisiana in particular survival has depended upon some degree of mechanization.

Early attempts at mechanization were not too successful due to the inability to de-trash the cane. Both growers and processors suffered losses therefrom. Accordingly, the Thomson Machinery Co. undertook to develop a machine that would not only cut the cane top and bottom but also strip, or de-trash it. Designed primarily for Louisiana conditions, modifications to make it suited for other regions have yet to be worked out.

The Thomson harvester with three men can handle about 180 tons of cane a day, equivalent to the harvest of 100 laborers. It is a self-propelled, three-wheel rubber-tired vehicle, weighing 16,000 lb. Steering clutches are used on the two rear wheels for turning and maneuvering.

Two 50 hp diesels propel the machine and operate the cutting knives, cleaning and loading devices. Stripping is performed by a series of inclined chains with flexible fingers traveling in a slanting direction rearwardly as the machine moves forward. The chains not only remove trash, but also help to propel the cane into the harvester. A series of rotating discs with flexible fingers placed in opposite pairs, between which the cane passes, revolve with a planetary motion and help to remove remaining trash. (Paper, "The Mechanical Harvesting and Loading of Clean Fresh Sugar Cane in Louisiana," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 11, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers).

Discussion

J. L. Hipple
International Harvester Co.

LOADING cane from the harvester in field length presents a problem, though not a serious one. We found that an actual gain in sucrose was apparent when the cane was cut in short lengths, handled as a bulk crop, and ground in a 12 to 15 hour period. We arrived at a 14 in. length for the harvested cane. It can be handled in conventional elevators and dumped into the truck without sorting or piling as is necessary with the field length. As this method is adopted, more efficient handling of the storage piles at the mills can be worked out, eliminating the present use of heavy derricks.

Charts Aid Design of

DESIGN of expander piston rings is not a simple matter. Many factors must be weighed before a relationship can be established between outer ring diameter and radial wall thickness and the number of expander humps or support points.

These factors are:

1. Conformability.
2. Radial pressure shape.
3. Tension and unit pressure.
4. Spring rate.
5. Working stress.
6. Expander wrap.
7. Expander ventilation.
8. Fatigue life.
9. Stability or heat resistance of expander.

Conformability

Conformability is the capacity of the ring combination to fit various cylinder shapes.

Our experiments indicate that:

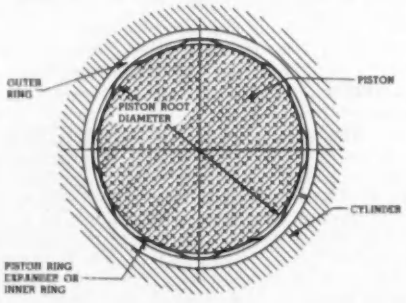
1. For a given diameter and expander design, the conformability of the ring combination decreases as the outer ring radial wall thickness increases. Simply stated, it appears that the higher radial wall, because it is stiffer, finds it harder to adjust and fit irregular cylinders.

2. Conformability of a given ring combination improves as the number of humps on the expander is increased to a certain optimum point, after which there seems to be no advantage to increasing the number of humps, as far as conformability is concerned.

Radial Pressure Shape

It is considered good design to have a uniform radial pressure to assure a quick seat and immediate seal. When the outer ring radial wall is too low, the humps on the expander register strongly in the radial pressure shape of the combination.

What Piston-Ring Expanders Can Do



THE expander piston ring consists of a cast-iron outer ring and a steel expander or, as it is sometimes called, an inner ring.

The placement of the expander behind the piston ring accomplishes several purposes, according to the authors:

1. It allows a considerable increase in piston-ring tension or load.

2. It increases the conformability and flexibility of the piston-ring combination.

3. It helps stabilize the piston in the cylinder.

Piston-ring expanders are being used more and more, they say, particularly as original equipment in new engines.

Piston-Ring Expanders

Douglas W. Hamm and Kenneth J. Nisper, Muskegon Piston-Ring Co.

Excerpts from paper, "Engineering Piston-Ring Expanders for Maximum Performance and Life," presented at SAE Summer Meeting, Atlantic City, June 1, 1952.

Our evidence indicates that, as far as the shape or seat pattern of an expander-ring combination is concerned, the higher outer ring radial wall aids in smoothing out the effect of the expander humps and helps produce a uniform radial pressure curve.

Increasing the number of humps on the expander also smoothes out the radial pressure curve, ensuring a better seat and improved and quicker seal.

Tension and Unit Pressure

In expander design, tension is usually expressed as "tangential tension." It is obtained by closing the outer ring and expander combination over a plug of diameter equal to the root diameter of the piston groove for which the ring is being designed, the closing being done with a flexible, fairly thin, steel band, which is wrapped around the outer ring and then, by means of a tangential pull on the opposite ends of the flexible band, the amount of load required to close the combination under such conditions is measured. (See Fig. 1.) (The inherent friction is removed during the tension testing by vibration or rapid impact blows.)

Assuming we know the unit pressure required to do a satisfactory job, we can calculate the gross tangential tension of the expander and ring combination by using the simple formula:

$$T = \frac{BDP}{2}$$

where:

T = Gross tangential tension, lb

B = Bearing width of outer ring, in.

D = Ring diameter, in.

P = Unit pressure, psi

Next, we can find the net expander tension by subtracting the tension of the outer ring alone from the gross design tension.

Unit pressures for expander-type compression rings will vary from 40 psi to 100 psi. Units pressures for expander-type oil rings are higher, usually being 150 psi to 500 psi, depending on the type of ring and the job that the ring is being asked to do.

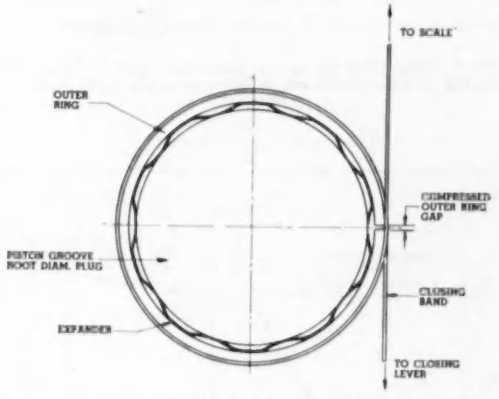


Fig. 1—Tangential tension checking fixture for piston-ring expanders

Spring Rate

A typical spring rate curve for a piston-ring expander (Fig. 2) shows that, toward the end of the deflection, the tension builds up very rapidly with a small amount of deflection. Since the expander loses its tension generally along the same curve, the typical expander will lose considerable tension because of outer ring wear. It is desirable to select an expander having a spring rate curve with the

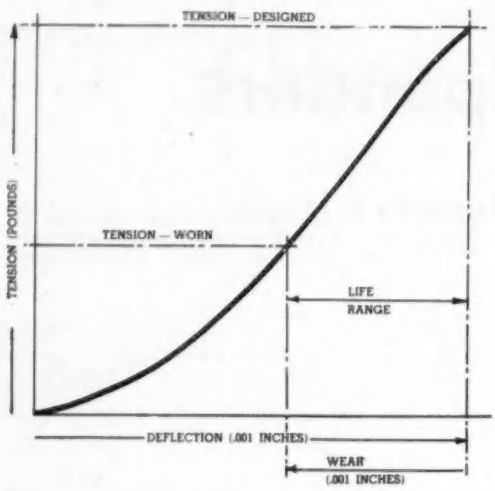


Fig. 2—Typical spring rate curve of piston-ring expander. Shows relationship between tension and deflection of expander and wear on outer ring

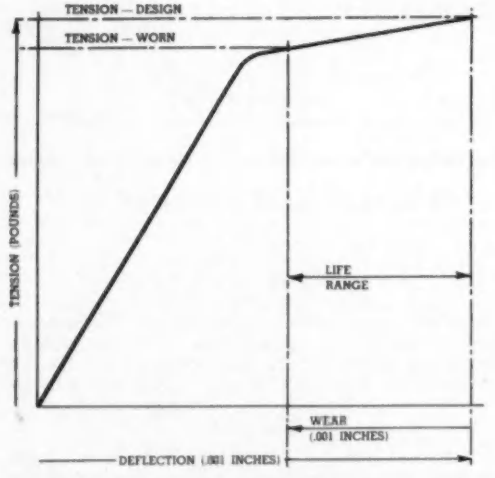


Fig. 3—Theoretical spring rate curve of piston-ring expander. Shows relationship between tension and deflection of expander and wear on outer ring

least slope, designing for a large deflection to obtain the given tension.

Let us look at a spring rate curve that is perhaps theoretical, but that has a more desirable shape (Fig. 3). Note that the important portion of the curve, as far as ring wear life is concerned, is fairly flat, assuring little tension loss as a result of the outer ring wear. Obviously, to get the tension of the combination up to a level for satisfactory performance and still keep the deflection at a practical limit, the steep part of the curve may be necessary at the start; however, the extent of this steep portion should be such that, during the life of the ring combination, the tension of the expander remains on the flat portion of the curve.

Working Stress

The stress in the expander has a direct bearing on its fatigue life and stability. Fig. 4 shows a typical stress layout for an expander. Note the high stress points.

The greater the corner or hump radius, the less the stress on the hump. This lower stress can result in an improved fatigue life and also better tension stability under heat. Thus, there will be less likelihood of breakage across the hump and permanent set on the hump.

The stress at any point in the expander is inversely proportional to the square of the material thickness. As the steel thickness is increased, the working stress at any point decreases rapidly.

If the tension of the expander is high, the load on each hump is also high. The stress at the hump, which, incidentally, is a high stress point, is directly proportional to the load. Thus, the stress on the hump is proportional to the tension of the expander.

The more humps or support points desired on a given expander, the shorter each section or crimp length will be. A longer crimp length will result in a lower stress. This is because the longer the crimp length, the greater the wrap of the expander on the bottom of the piston groove and on the inside diameter surface of the outer ring. The number of humps (or support points) should be such as to give optimum conformability and shape and, at the same time, keep the stress level at a safe working figure.

Wrap

The amount that the expander wraps on the inside diameter surface of the ring is determined by the diameter of the ring and the corner radius (or hump radius). The amount of wrap on the bottom of the piston groove will be determined by the root diameter of the groove and the shape of the expander portion that makes contact with the bottom of the groove. The total wrap of an expander consists of the sum of the wrap on the bottom of the piston groove plus the wrap on the inside diameter surface of the ring.

As the total wrap is increased, expander fatigue life is also increased. The wrap at the high stress points results in an even distribution of the loads at these points, which then decreases the top level of stress. A higher wrap also results in a shorter effective lever arm, thus lowering the working stress. Further, increased wrap reduces the wear on the ex-

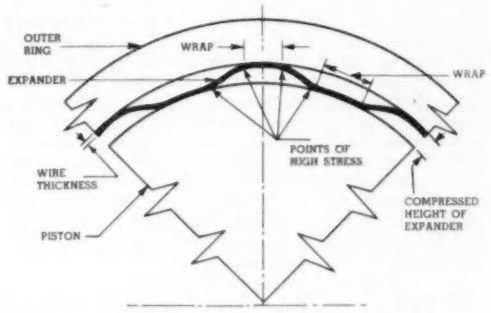


Fig. 4—Layout showing section of compressed piston-ring expander with design factors noted

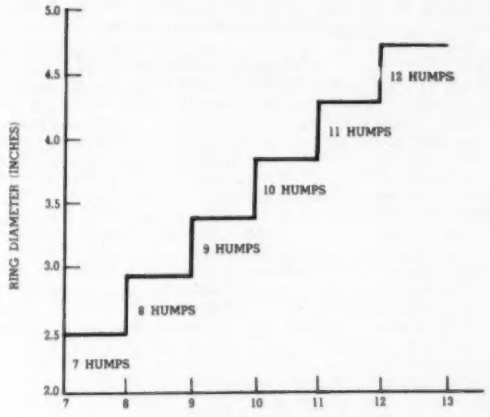


Fig. 5—Number of humps on expander for given outer ring diameter

pander where it contacts the piston and where it contacts the inner ring.

Expander Ventilation

The ventilation of an expander is the amount of opening that is created in its construction or blanking on the original strip.

The total opening in an expander should be such that a free movement of oil through the ring and through the expander to the bottom of the piston groove openings is always possible for the life of the combination. Before the openings can be definitely established, the type of ventilation at the bottom of the groove should be known. The ventilation in the expander is then chosen so that there is the least possible blocking action and also good support for the expander.

It is generally good design to have no less than 0.30 sq in. of total opening. This area can, of course, be obtained through a variety of means: straight notches, center slots, radius notches, elliptical notches, or combination of these.

The openings should be located symmetrically about the axis, so that the expander can be placed in the groove with either side up, simplifying installation. Further, the openings should be located so that they do not concentrate the stress. The rule should be, keep the stress concentration points inherent in the shape of the openings away from the high stress points of the expander. Also, it is necessary that the openings be located so that the stresses are well balanced. Thus, the stress should not be low at the point where the expander contacts the piston if it means that the stress will be too high at the hump on the expander. The design should provide a safe and uniform level of stress at all locations.

Fatigue Life

The expander should never break in the engine. Maximum working stress in the expander, distribution of the working stress, type and location of ventilation openings, together with freedom from

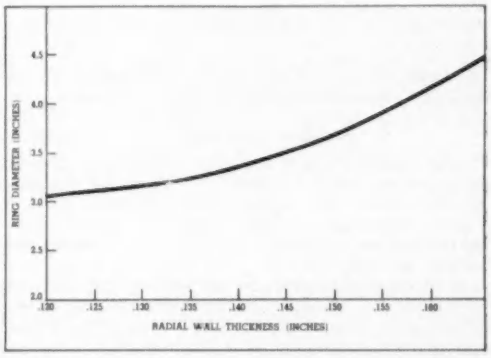


Fig. 6—Radial wall thickness of outer ring plotted against diameter

roughness and burrs along the edges of the openings all contribute to the fatigue life of the expander.

A satisfactory material for expanders is tempered spring steel similar to SAE 1095, with a hardness of 69–72 Rockwell superficial 30 N scale.

This type of spring steel is being made into wire of high quality and maximum uniformity. It is usually highly polished on all surfaces, with a complete freedom from surface imperfections, such as scratches and pits—any of which could affect expander fatigue life. The material is usually made with rounded radius edges to eliminate any chance

Table 1—Design Data for Expander Piston Rings (Suggested for SAE Handbook)

Cylinder Diameter, in.	Average Outer Ring Radial Wall Thickness, in.	Number of Expander Humps
3	0.116	9
3 1/16	0.120	9
3 1/8	0.125	9
3 3/16	0.130	9
3 1/4	0.133	9
3 5/16	0.138	9
3 3/8	0.141	9
3 7/16	0.142	9
3 1/2	0.145	10
3 9/16	0.147	10
3 5/8	0.148	10
3 11/16	0.150	10
3 3/4	0.151	10
3 13/16	0.153	10
3 7/8	0.154	11
3 15/16	0.155	11
4	0.157	11
4 1/16	0.158	11
4 1/8	0.159	11
4 3/16	0.160	11
4 1/4	0.162	11
4 5/16	0.163	12
4 3/8	0.164	12
4 7/16	0.165	12
4 1/2	0.166	12

of stress concentration, which might adversely affect the expander fatigue life.

Stability—Heat Resistance

The effective life of the expander will be directly proportional to its ability to retain the designed tension under the temperatures imposed on it in engine operation. Checks made of expanders installed in test cars have indicated that the tension loss is very important.

It is a real challenge to the piston-ring engineer to design an expander of improved stability under heat. This is particularly difficult because expanders generally operate at a high level of working stress. It is not unusual for them to lose 50% of their designed tension in a 100-hr heat test at 450 F. All the leading brands suffer from excessive tension loss under heat, so that considerable work is being done to improve this situation.

Some applications require that they be pre-loaded and heated so that when they are actually used in the engine, the stability is improved. Another method is to design the original tension higher than actually necessary, so that the tension loss under heat when subtracted from the original tension will still leave the expander with sufficient tension.

Design Charts

We have prepared charts that show the relationship between piston-ring diameter and the number of humps in the expander (Fig. 5) and the relationship between the ring diameter and its radial wall thickness (Fig. 6).

In preparing these charts we omitted direct consideration of tension and expander ventilation because they are directly involved in some of the other design factors. For instance, the type of expander ventilation will affect the working stress, which is one of the major factors in our charts. Further, our studies were based on one tension level, which we consider average for present-day applications. Work done on different tensions has, however, indicated that the data will apply to various tensions.

Further, we have determined, also as a limitation, the maximum number of expander humps as the number that can be produced in a polygonal type expander. As the number of humps on the expander is increased, the crimp length is decreased. Thus, with a large number of humps, the wire thickness necessary for a given tension is decreased.

Our experience has indicated that it is not desirable to use a wire less than 0.012 in. thick. Further, it is necessary to provide sufficient crimp length so that there is room in each crimp for satisfactory expander ventilation. This also helps establish the maximum number of humps. The cost of the expander must also be considered, for as the number of humps is increased, the cost of producing the expander is increased. We have thus established on our charts the maximum number of humps that can be practically used.

Likewise, we have established a limitation on the maximum outer ring radial wall thickness that can be used in an expander-ring combination. The limitation here is governed by the groove depth provided on the piston.

We also set limits for each design factor so that we could determine whether a given expander-ring combination satisfied the factor or not. These are:

1. Minimum conformability: 0.008 in. out of round.

2. Shape: maximum radial pressure variation of ½ lb.

3. Spring rate: 4-lb maximum tension for 0.010-in. hump deflection.

4. Maximum working stress: 260,000 psi.

5. Minimum fatigue life: 7500 cycles with 0.060-in. deflection for each cycle.

6. Stability: 35% maximum tension loss after being compressed 100 hr at 450 F.

For some time the SAE Handbook has included such design data for piston rings as ring groove root diameter and radial wall thickness. There have been no data on expander rings. We feel that some such data as that shown in Table 1 should be included.

Expander piston rings are used in great quantities in automotive engines. A compilation of basic expander-ring data would be of considerable benefit.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Excerpts from Discussion

By Stuart Nixon
Sealed Power Corp.

IT IS unfortunate that the authors consider only one design of expander and not the general subject, including the butting type; for design influences the relationships to such an extent that the proposal to make up standards for thickness of ring, wire thickness, number of crimps, as was proposed some years ago, is well nigh impossible.

The authors have also side-stepped the consideration of wire thickness and total rise of the crimp-type expander, except for an indirect reference to tension. Some of the unit pressure figures may seem frightening, but actually the action of an expander ring is so different that the engine, which fortunately cannot read, does not know the difference and does not respond with more running drag (kinetic friction) in the same proportion. In my opinion the unit pressure figures are apt to give very false impressions and, further, have such a range that they cannot be used without interpretations.

The authors' conformability figures, which are one of the first considerations of an expander-type ring, should also take into consideration the use of expander-type rings in relatively true bores, where this property is not essential and permits the use of thicker rings and adjustment on the expanders, to obtain other benefits such as evidenced in the V-8 engines.

The peculiar radial-pressure polar curve possible was noted some years ago, but the examination of a great many rings after miles of service does not show that it reflects in any way on the performance. It is probably not as important a consideration as what the authors call "spring rate," which is a function of the span and hence the number of crimps.

Ventilation of oil rings and expanders is, in general, an over-emphasized subject. Not much is known about how extensive it should be and how important it is, except that there are indications that the amount of ventilation required is a function of the engine rpm and at low speeds does very little to effect drainage.

The authors use a heat resistance temperature of 400–500 F, which sounds a little high for general comparison. In our work 350 F has been considered the maximum temperature a spring is subjected to. The heat loss is not so great at this range. Expanders are not now used in top grooves and even the materials tried, that will stand this higher temperature when used in the top groove, have not improved performance, due to other factors that interfere with their functioning.

The authors might have clarified their presentation if they had deduced from their investigation some empirical equations that would apply. In our investigation we have found that "wrap around" materially affects the effective length of the spring section and should be a minimum. The minimum operating clearance behind the ring controls the expander-ring design, which fortunately ties in with the reduced thickness of the ring to result in flexibility If the minimum clearance is assumed, then the ring thickness is a determinate for:

$$\text{Ring thickness (max)} = \frac{\text{Bore diameter} - \text{groove diameter}}{2} - \text{clearance}$$

From easily deduced equations it can be seen that the tension is a function of the cube of the wire thickness and the cube of the ratio of crimps to groove diameter. In other words, if the rise is too high for the groove, increase the number of crimps or change the wire thickness. To get a soft spring—that is, one of a low pressure rise, then the minimum number of crimps to obtain the greatest span between crimps is advisable. If we discount the effect of having few lobes on the radial-pressure diagram, then the number of crimps indicated by the authors is far too many.

Authors' Closure To Discussion

WE ARE aware of the fact that the scope of our paper is such that it deals with only a part of the total problem of piston-ring expanders.

We endeavored to limit our presentation to the flat-wire radially deflected type of piston-ring expander. We believe that this was the correct procedure inasmuch as the butting type of piston-ring expander is not, at the present time, in production use in any automotive application. We are, of course, referring to the circumferentially compressible expander used in conjunction with another ring member.

We are particularly interested in striving for a uniform-radial-pressure polar curve on expander-type rings. We believe that the concentration on this item in connection with expander rings has been neglected for many years. We see no reason for concentrating on a snap ring, endeavoring to get a uniform radial pressure, and then forgetting about the need for a uniform radial pressure on expander-type rings.

We are inclined to disagree with Mr. Nixon on the subject of ventilation of oil rings and expanders. We have encountered many situations where the openness of the oil-ring combination has been a definite advantage. We believe, definitely, that the life of the expander-ring combination is increased if the ventilation is correctly designed, both for location and for amount of opening.

We are aware that our heat test data on expanders was on the high side as far as temperature is concerned. We have been using a temperature of 450 F for this investigation. While this higher temperature is not often encountered in the oil-ring groove, it has emphasized to us the great need for stability in piston-ring expanders. The tension loss, even on the lower temperatures, is excessive in our opinion.

It was our hope that our paper on piston-ring expanders would be a start, long delayed, of the presentation of accurate basic data which can be applied to this class of piston rings. We feel definitely that some of this information can be standardized and used as a part of the regular SAE data for piston rings.

Ways to Lower Costs Discussed at Diesel

THE diesel engine has become the chief source of power for many types of ground vehicles chiefly because: (1) it isn't so choosy about its fuel as the gasoline engine and (2) it uses less fuel.

These obviously add up to substantially lower operating costs. They also mean that use of the diesel is aiding conservation of our petroleum resources.

So it is appropriate that the technical papers at the SAE National Diesel-Engine Meeting were all concerned with these same phases of the diesel problem.

In regard to conserving our reserves, the dinner speaker, Edwin J. Putzell, Jr., secretary of Monsanto Chemical Co., went even further. He suggested that if we are to obtain the increased supply of power needed in even the next 25 years, we must resort to atomic power. Otherwise, he warned, we will be delving too deeply into our dwindling supply of petroleum resources.

Already, he pointed out, our demand for crude oil has begun to outstrip domestic production, so we have become a net importer. In addition, as wells must be drilled deeper and as the ratio of strikes to dry holes decreases, costs will go up despite technological improvements.

We do have a few large, undeveloped water-power sites left, he continued, but most of them will require a higher capital outlay per unit of output and other expenses to deliver electricity at the same low cost.

Adding uranium and thorium to our fuel inventory, the speaker said, will make possible better utilization of our limited natural resources. We will be able to make more oil and gas available for uses in which they have unique value.

Hydrocarbons are basic to the production of many kinds of plastics and of synthetic rubber. Further, it seems we have only scratched the surface in seeking out and developing useful products that have as their basis the hydrocarbons we are now pumping from the ground at an alarming rate.

The guided missile also, by its nature, requires a combustible fuel. Modern types, he pointed out, are, for the most part, burning hydrocarbons in one form or another.

Thus, he reasoned, the development of nuclear fission to provide an alternate source of energy to supply motive power is of extreme importance in the face of other unique uses for petroleum already here or on the horizon.

Moreover, the task of designing, building, and perfecting atomic engines for practical, nonmilitary use presents one of the great industrial challenges to this generation, he concluded.

Meanwhile, although, as is well known, an atomic engine to power a submarine has been developed and is now under construction by the AEC, the diesel engine is still going to be busy running our vehicles for some years to come.

Engineers are still hard at work trying to understand it and the complex fuels and lubricants it consumes, finding new uses for it, finding ways to make it more flexible.

Among the new tools that are helping us understand it are two heretofore highbrow research instruments, the spectrograph and the electron microscope.

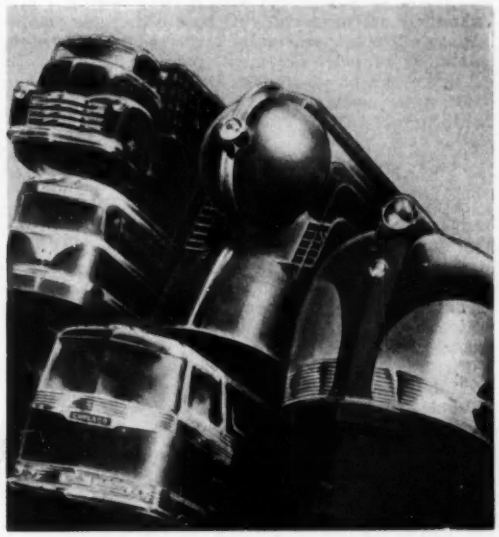
It appears that they are aiding both lubricating oil research and engine maintenance control.

Oil Research

The electron microscope has become, according to John L. Broughten, Union Oil Co. of Calif., particularly useful for studying the mechanisms of oxidation and detergency, and the effects of additives on the properties of the base oil.

These mechanisms can be studied with the electron microscope because its high resolving power allows tremendous magnification. Photographs taken at 1500 diameters were actually enlarged to 45,000 diameters. At this magnification many facts can be learned about the macromolecular organization of matter (which principally includes the colloidal range) that just couldn't be studied before.

Meeting



The macroparticle activity of lubricating oil includes both oxidation and detergency effects.

Broughten said the relative solubilities of lubricating oil additives of different compositions can now be studied. These are important in analyzing detergency properties of compounded oils, which just weren't understood at all before the use of the electron microscope.

He also reported application of the microscope to investigation of the effect of mixed additives on solubility, dispersancy, and oxidation.

In a study of detergency, he said, the microscope can be used to examine particle size, shape, and structure, as well as particle orientation . . . and at magnifications far beyond the resolution of the light microscope.

It can be used in determining the relationship of additive concentration to dispersive action. It is

General Chairman R. O. Slattery (left) got together before the dinner with SAE Diesel Engine Veep Walter Ainsley and Meetings Vice-Chairman F. A. Robbins. N. C. Beck (right) chairman of the St. Louis Section and a member of the general committee that arranged this meeting, which was held with the cooperation of the St. Louis Section

extremely useful in studying base oils under oxidizing conditions, principally because the oxidation particles, such as polymers, resins, and oxy acid products, can be readily identified and distinguished from other contaminants. The effective oxidation inhibition of various additives can be examined.

Maintenance Control

Both the spectrograph and the electron microscope are already being used by the railroads to control diesel maintenance procedures through examination of new and used crankcase oils.

Ray McBrian and L. C. Atchison, Denver and Rio Grande Western Railroad Co., have used them to unearth what they believe are some basic facts about oils.

First, their studies indicate, new, unused lube oils containing additives are not true solutions but colloidal suspensions. The pattern or type of suspension dispersancy is important in operating performance, they argued, and in this can be found the answer to such questions as:

Why can't additive oils be mixed?

Why is base stock solvency important?

Why can additive depletion occur?

Why can oil shipments with the same apparent additives be found that give entirely different results in service?

Moreover, while a straight mineral oil shows no pattern under the microscope, unless contaminants are present, each additive oil has a definite structure, which can be "fingerprinted" by the microscope. This pattern is affected by base stock solvency as related to V.I. The oil with the most uniform dispersancy pattern seems to give the best overall service.

These investigators have also found that:

1. The structure and pattern of dispersion in the detergent-additive oil determine the pattern in which dirt, carbon, and the like remain grouped in the used crankcase oil. This pattern or grouping tendency appears to influence the rate of wear, lacquering, deposits, and condition of ring breakage.

2. New, unused additive oils can have their normal dispersion pattern completely changed by residual impurities in either base oil or additive. Even when impurities cannot be detected by regular analysis methods, the structural change does show up in microscope pictures. Thus, a quick control method is to examine with the microscope each additive oil shipment to see if the additive dispersancy pattern is right. Similarly can used oils, through introduction of oxidizing agents as contaminants, result in loss or change of additive dispersants. Also, a breakdown of oil in service changes the additive pattern.

3. Medium (50–60) V.I. oils containing the alkaline earth group additives give the best overall dispersion and the best service results.

To get good wear results, the authors suggested maintaining in the oil at all times a fine dispersion of additives plus contaminants of less than ½ micron size.

They feel the electron microscope will predict oil breakdown and the formation of oxidation and lacquer deposits.

Additive depletion is shown by the loss of the oil dispersancy pattern.

The spectrograph can also be used to study diesel conditions by the examination of the crankcase oil, according to McBrian-Atcheson and H. R. Sennstrom, American Locomotive Co.

An examination of the new oil shows what addi-

Between sessions (left to right) R. Tom Sawyer, American Locomotive Co., L. V. Armstrong, Ingersoll-Rand Co., F. S. Chapman, Franklin Institute, and O. D. Treiber, Hercules Motors Corp. talked over some of the papers heard at the meeting

tive metals are present, then when the used oil samples show the presence of other metals, which are used for engine parts, wear of these parts is taking place.

It is even possible to determine how much of each metal is present in the used oil sample by a method described by Sennstrom.

A known amount of a metal—lithium in the form of lithium carbonate—not found in crankcase oil is added to the oil sample before it is burned in the spectrograph. The densitometer is then used to determine the relative densities of the various indicating spectrum lines and compared with the density of the lithium line. The amount of each element appearing in the sample is then calculated.

To simplify his investigations, Sennstrom confined his determinations to six elements: lead, copper, iron, chromium, aluminum, and silicon.

With the aid of laboratory tests, he set a base amount for each of these elements. The presence of this amount was considered to indicate normal operation in the locomotive engines of his company. These amounts are: lead, 10 parts per million; silicon, 6 ppm; iron, 20 ppm; chromium, 5 ppm; aluminum, 3 ppm; and copper, 4 ppm. When these amounts are exceeded, they act as danger signs, indicating trouble ahead.

Briefly, excess amounts of lead and copper generally seem to indicate bearing troubles; chromium indicates liner wear, if chrome-plated liners are used, or water leakage. Aluminum indicates scoring of aluminum pistons, if they are used. Silicon shows that dirt—particularly airborne dirt—has entered the engine.

Iron alone indicates excessive wear of gear trains might be anticipated. High iron, copper, and lead usually mean bearing trouble, for the iron is probably coming from excessive crankshaft wear.

High iron plus high chromium and aluminum usually mean ring difficulties, involving excessive wear of rings, cylinder walls, and pistons.

In short, the spectrograph can show the condition of many critical engine components without resorting to frequent engine inspections. It can save money in two ways: through preventive maintenance and through indicating when not to spend money on overhauls that aren't needed.

McBrian, in discussion, also mentioned electron microscope studies of diesel fuel and gasoline. This preliminary work indicates, he said, that additives may turn out to be as promising a way of obtaining dispersancy of particles in fuel oil as they have been with lubricants. He said that the electron microscope is proving most helpful in studies of gasoline gum content—even of gasolines that pass all standard tests for gum content.

Combustion

One phase of the complex combustion process—the effect of fuel additives—was reported by W. Chow, O. A. Uyehara, and P. S. Myers, all of the University of Wisconsin.

They found that the cetane number obtained with additives may be more or less advantageous than natural cetane number, depending on both the fuel and the operating conditions. Further, it appears that the mechanism by which additives increase the cetane number may be quite different from the fuel characteristics that cause a natural increase in cetane number. The latter conclusion is based on data obtained with the help of a unique hot motored pressure-time diagram.

DINNER SPEAKER EDWIN J. PUTZELL, JR., secretary of Monsanto Chemical Co., told his audience that atomic power is necessary to supplement our supply of energy. It will, he said, make possible the better utilization of our dwindling natural resources

The great variety of results that the University of Wisconsin investigators obtained with different fuels, additives, and additive concentrations led Martin Berlyn, American Locomotive Co., to comment that these investigations were a monumental indictment of the open-chamber engine.

Originally, he said, the diesel was designed to burn almost anything, but now it is much too dependent on fuel properties. He suggested that a new approach is needed to develop open-chamber engines that don't make such high demands on the fuel. He suggested that a restudy of the injection system might prove fruitful.

Railroad Diesels

The amazing flexibility of the railroad diesel produced by Electro-Motive was described by E. W. Kettering, T. B. Dilworth, and J. M. Norris.

First, all engines are alike except for the number of cylinders, for there is but one engine cylinder, with all its associated parts—heads, valves, injectors, cylinder liner, piston, and so on. This cylinder is used in all models.

Similarly, there is but one traction motor, which is used in everything from switchers to streamliners. There are two traction generators, one auxiliary generator, one fuel pump motor, two fuel pumps, and so on.

Then, by using different transmission gear ratios,

SESSION CHAIRMEN, who helped to make the meeting a success, were:

Arthur Heintze, Sinclair Refining Co.
Adam Ebinger, St. Louis Public Service Co.
A. J. Jeude, Nordberg Mfg. Co., Busch-Sulzer Division
L. A. Wendt, Shell Oil Co.

SESSION SECRETARIES, whose reports of the discussion helped to make SAE Journal coverage of the technical papers more complete, were:

W. H. Cowdery, Sinclair Refining Co.
Harry Decker, Phillips Petroleum Co.
F. J. Huber, Nordberg Mfg. Co., Busch-Sulzer Division
Julian Ryan, Shell Oil Co.

THIS JOURNAL STORY is based on the following papers (and discussions that took place following the presentation of the papers):

"Practical Use of the Spectrograph and Electron Microscope for Story of Diesel Engine Conditions" by Ray McBrian and L. C. Atchison, Denver and Rio Grande Western Railroad Co.

"An Electron Looks at Detergent Oils" by J. L. Broughten, Union Oil Co. of California

"Diesel Maintenance Control by Spectrographic Means" by H. R. Sennstrom, American Locomotive Co.

"Diesel Locomotive Bug Hunters" by E. W. Kettering, T. B. Dilworth, and J. M. Norris, Electro-Motive Division, GMC

"The Effects of Additives on the Diesel Combustion Process" by W. Chow, O. A. Uyehara, and P. S. Myers, University of Wisconsin

"Diesel Engines in Fork-Lift Trucks" by L. C. Daniels, Buda Co.

"Procedures Used in the Development of the Barnes and Reinecke Air Force Diesel Engine" by E. W. Spannhake, Barnes and Reinecke Co.

* * *

These papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Transactions.

They are also available in full in multilithographed form from SAE Special Publications Department, at 25¢ a copy to SAE members and 50¢ a copy to nonmembers.

one can produce either a slow freight or a fast passenger train. To obtain increased horsepower, the diesels are simple to hook together for multiple unit control from a single cab operated by a single crew. For example, four 1500-hp units can be hooked together to give 6000 hp.

Thus, the authors pointed out, large-scale production comes not from the number of locomotives built, for their number is relatively small, but from the number of like parts in each locomotive—and in each model—which is high.

The economy of this type of production has been so great, they reported, that the price per horsepower has not changed since 1936, despite the great increase in the prices of materials and labor.

Fork-Lift Trucks

The diesel is coming into its own also as power for fork-lift trucks, according to L. C. Daniels, Buda Co. In this case, the diesel's safety features did the trick.

In hazardous areas, where fires or explosions may occur, neither the gasoline- or the electrically powered truck is fully satisfactory, he said, despite safety precautions.

The diesel, on the other hand, appears to be a natural for this sort of work. Its fuel has an extremely low flash point, so it isn't likely to explode or burn. An electrical system is not necessary, so electrical sparks need not be feared. It is also simple to control its operation so that carbon monoxide, which might collect in closed areas, is not formed.

Because of the safety features, the author said, the port authorities allow diesel-powered lift trucks to be refueled, serviced, and stored right on the docks. On the other hand, the gasoline-powered truck must be removed to a garage for these operations. With the diesel, the cost of garage facilities can be saved, as well as the time and labor required to transport the trucks back and forth between the garage and the dock.

Gasoline-Oil-Burning Diesel

The development of a diesel engine capable of burning anything from No. 2 distillate to 100-octane gasoline was reported by E. W. Spannhake, Barnes and Reinecke Co. It was built for the Air Force, he said, which wanted an extremely lightweight engine that would be capable of burning any fuel that might be found around an airport.

The present model, which was developed in record time, according to the author, is a 2-stroke, port-controlled, one-cylinder job.

Special features include, he said:

1. A scavenging system that gives a centrally symmetrical mushroom-type flow.

2. An injection system that, through a switching arrangement, can change from diesel fuel to 100-octane gasoline smoothly and, with an adjustment in timing, still retain the same peak combustion pressure.

3. Nozzles that give high fuel penetrating power, even when the engine is supercharged.

Gripes Pave Way For Truck, Bus Advances

DISCONTENT with current vehicle design and operation, voiced at the SAE National Transportation Meeting, Pittsburgh, Oct. 22-24, forecasts a fruitful future in transportation engineering. That's because fresh thinking and new developments will produce from the seeds of discontent, sowed by many of the 400 at the meeting, a rich harvest of improvements.

The discontent felt by transportation men reflects the state of mind of American technology. That's what Dr. W. A. Gruse, of Mellon Institute of Industrial Research, told the dinner audience. In listing the essentials of an active, sound technology, he said:

"There is a liberal dose of the divine dissatisfaction which whispers to each of us, 'It isn't enough.' It is the same spirit which prompts an engineer to note how his forebears have done it, and tells him there is a better way. Just as soon as people begin to think they have a pretty good arrangement as matters stand, and they don't want things unchanged, then they already are on the way out."

Five Areas of Discontent

An it's-got-to-be-better attitude permeated the technical sessions and corridor chats. If gripes produce progress, then improvements will come from the faults found with:

- Braking systems that can't prevent skidding on slippery road surfaces.
- Regulatory rulings that limit vehicle gross weight and cut into payloads.
- Control systems that are not 100% foolproof, that lack desired properties.
- Parts and components that fail unexpectedly in service.
- And fleet operations that don't move "the mostest pounds for the fewest dollars."

The flaw-finders focused on braking under icy conditions. Opinion wielder on this subject, A. C. Gunsaulus, of Goodyear Aircraft, got backing on this assertion: It's pretty tough for the vehicle driver to maintain complete brake control on slippery roads.

As Gunsaulus explained, the moment the driver overbrakes on ice, his wheels stop rolling and start sliding. Next thing he knows is that the vehicle is skidding. Seldom can the driver anticipate overbraking and correct it, contended Gunsaulus. At this point spiritual appeal rather than mechanical measures remains his only hope for salvation.

Man-made laws as well as Nature's hazards have contrived to make unhappy the lot of truck engineers and fleet men alike. Restrictive legislation on total vehicle weight reduces payload-carrying capacity per pound of truck.

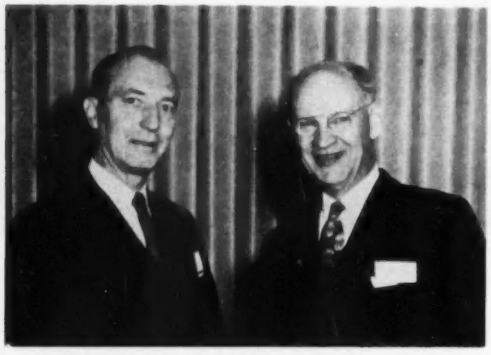
According to "Nev" Bauman, of White Motor, the truck industry can't plan its future as do other forms of transportation. Each of the 48 states regulates highways as to weight limits. And these limits are subject to change at each meeting of the legislature. "Motor transport does not have the stability or flexibility in planning the future with a knowledge that its road bed capacity will not be

subject to political pressures rather than economic fact," said Bauman.

Axle load restrictions on top of total weight limitations combine to complicate things for truck designer and operator alike.

As Bauman explained, even if state laws permit 58,000 to 60,000 gross vehicle weight, the trucker rarely realizes this ceiling. That's because often he'd have to exceed allowable 18,000-lb axle limits to carry the maximum load.

Rising operating costs strengthen the argument for replacing pounds of vehicle with pounds of revenue-producing load, said Orville Brouer, of Swift & Co.



Plans for the meeting were made by the activities headed up by these two SAE vice presidents. F. W. Kateley (left) is top man of the Truck and Bus Activity Committee and Linn Edsall heads the Transportation and Maintenance Activity Committee

SAE Presidential Nominee Robert Cass (left) was welcomed by General Chairman E. S. Page

Power sources for control leave something to be desired in certain cases, claimed some engineers at the meeting. New requirements may open the way to systems other than pneumatic and mechanical ones for these applications. For example, operators of large buses are restive about steering systems and ways of actuating devices like doors, windshield wipers, and brakes.

Another area of engineering unrest emphasized at the meeting originates from service complaints. What comes off the design board as a foolproof, formula-tested product may fail in the field long before the engineer expected it to.

Short-lived parts should never get past engineering design, agreed Gil Roddewig, of GMC Truck & Coach. But the facts of life are that they do, he added, particularly when there's no service experience to back up the design theory. So the next best thing is to remedy the design flaw just as soon as the field complaint reaches the plant. To prove that the corrected design works, you've got to put it through a lab test that duplicates the service conditions which brought on the original failure.

It's in this area of experimental testing techniques that we need improvements, noted Roddewig.

Not Enough Sell

Fleet operators subjected themselves to an even more probing self-critique. Ted Preble, of Tidewater Associated Oil, summed up the discontent voiced by his fellow operators when he said:

1. Top management too often fails to recognize and understand the intricacies and importance of fleet management. That's sometimes because . . .

2. Highly competent vehicle operators can't seem to sell management on the importance of their functions.

Frustrations brought about by this condition are not uncommon amongst the fleet operator fraternity. Suppose an operator, with an unswerving desire for lowering costs, asks management to buy new vehicles to save fleet operating costs. Often as not he'll be turned down on the basis that the money might better be invested in the company's main business . . . refining petroleum, baking bread, or manufacturing soap.

Law makers can be just as distressing to the fleet manager, advised Gavin Laurie, of Atlantic Refining. For example, an operator can spend years refining maintenance practice and perfecting operating techniques to the Nth degree. But a change in one state law, lowering permissible axle loads from 20,000 lb to 18,000 lb, can offset all the gains he has achieved through the years.

Each challenge to right the wrongs in transportation engineering was matched with ways to hurdle the obstacles. Some were old, some were new, some show promise, some are yet unproved. But in digging into all, discussers found a high rate of return

Performers at Dinner

Chief dinner program participants were (left to right) Dr. William A. Gruse, who gave the dinner talk; K. G. Scantling, chairman of the SAE Pittsburgh Section; and Past-President R. J. S. Pigott, toastmaster

THE Transportation Dinner on Wednesday evening was featured by a talk from Mellon Institute's W. A. Gruse on "American Technology —A State of Mind" . . . and by the first SAE appearance since announcement of his nomination of 1953 SAE Presidential Nominee Robert Cass. SAE Past-President R. J. S. Pigott officiated as toastmaster at the event which drew an attendance of more than 350. Pittsburgh Section Chairman K. G. Scantling welcomed the dinner guests in a brief talk at the opening of the dinner.

Gruse made his points about technology being a state of mind by telling a series of interesting historical incidents to illustrate his thesis. The state of mind, he emphasized, must be the state of mind of our nation's technical manpower . . . not just of one or two bright people. "In this country," he concluded, "we have made a pretty good country, the Communists notwithstanding. We have done it by our willingness to try new things and to go along with the results of research. But also, we have done it by our willingness to drag out dead horses."

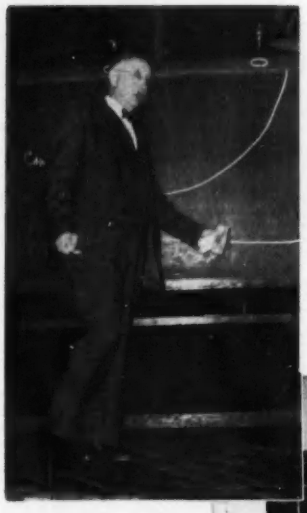
Typical of the incidents with which Gruse peppered his talk was the one about Chauncey Jerome of Connecticut, who was the Henry Ford of the clock industry back in 1820. Jerome was the first to realize that brass gears for clock movements need not be made laboriously by hand, but could be stamped out of sheet brass. . . . He made metal movements so cheaply he almost produced an international incident.

Off to London on other business, his son carried a dozen movements with him as a sales experiment. There, no one would buy them because they were so cheap they obviously could not be any good. Finally one dealer took them on consignment and sold them.

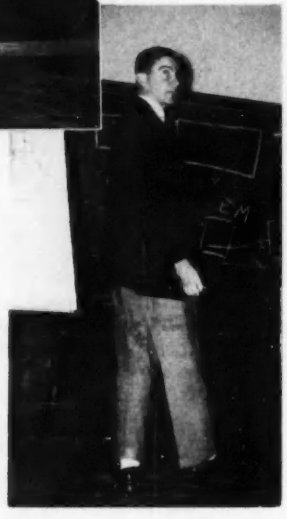
Hearing this report, Jerome then sent a small shipload of movements to an agent in England—which then had tariff laws, including an anti-dumping clause. Customs officers were empowered to take over at declared valuation any shipment which was obviously undervalued. . . . Jerome's clocks were declared at their American valuation. The British authorities said "This can't be true," promptly seized the clocks, and paid Jerome his price.

Jerome at once sent another shipment. The same thing happened and he sent a third. . . . Finally the customs officers realized it was bona fide business and that they had just been saving Jerome a lot of selling costs.

Chalk Talkers



Merrill Horine (left), of Mack, warned of the possibility of spending more money to save a pound of weight, by using light metals, than the revenue derived from extra payload achieved



Lew Kibbee (right), American Trucking Associations, queried Bob Fritzges about the functioning of hydraulic control systems

in paydirt potential. They were alerted to the possibilities of:

- An electrical sensing device that acts on brakes to prevent wheel skidding.
- The potential boost in payload available from light-weight metal parts and weight redistribution.
- Hydraulic power control with its positive action and possible weight saving.
- New bench testing techniques that duplicate service conditions.
- Sound philosophies on fleet management that can lower the cost of doing the job and gain recognition for it.

Goodyear's antiskid device was said to be an outgrowth of a development for airplane brakes. It keeps the wheels rolling at all times. This is a must, said Gunsaulus, to maintain control and to prevent skidding.

The setup, one for each wheel is fairly simple. Heart of the system is a small, d-c generator, called the sensing unit. Its voltage output is proportional to its armature speed, so properly hooked up, it can detect sudden changes in wheel speed. In addition to a condenser, two relays, and a battery in the system, there is a solenoid brake pressure valve.

Electrical Brain Bests Man's

If the truck wheel starts to slow down too rapidly, the sensing circuit becomes aware of it and opens the brake valve through the solenoid. That permits the wheel to recover rpm's. When the wheel reaches its proper speed, the sensing signal stops and the brake valve again closes. In effect, the sensing circuit fans the brake, but much more effectively than the driver could.

Gunsaulus drove home the sensor's merit with motion pictures of truck tests on the frozen surface of Pine Lake, near Clintonville, Wis. The movies showed that a tractor-semitrailer combination jackknifed every time when braked on the icy surface. With the sensing device at work, the rig didn't skid and came to a normal stop.

The development is still in the experimental stage, said Gunsaulus. For example, no test work has been done with it on wet pavements. Goodyear doesn't plan to manufacture the device. It hopes that the industry will see some merit in it, work out the bugs now in the crude design, and make it an integral part of the vehicle.

In going to the payload problem, men at the meeting examined two approaches, and found merit in both. One way to make room for more revenue-producing load is to make the vehicle lighter by using parts of light-weight metals, such as aluminum. Another is to resort to design ingenuity in getting a weight distribution that allows more payload.

C. L. Burton and E. P. White, of Alcoa, cited case after case of aluminum redesigns that saved many pounds. They showed that for over 20 years truck and trailer builders have been able to reduce weight with aluminum without any penalty in part life or performance. Typical of the examples they mentioned are:

- Kenworth Motor Truck's newest model truck-tractor, in which 2760 lb of weight was taken out by using 3500 lb of aluminum alloys.
- Mack's weight-saving of 2300 lb in a tractor for West Coast use by going to aluminum castings, forgings, sheet, plate, and extrusions.
- International Harvester's entry in the light-weight tractor field. It has light-weight engine parts, transmission case, and driving axle.
- The 1936 truck and full trailer made by Sterling motor for Shell Oil. This combination saved 7187 lb and gave a bonus load of 1150 gal.

Mack's M. C. Horine warned engineers that a switch to light-weight metals is not merely a substitution. There is no such thing as interchangeable metals—even among steels. He also cautioned that weight-saving via light-weight metals reaches a point where the cost of the weight saved exceeds the additional revenue you get.

Redistribution May Net More

Bauman, of White, showed that the cost per pound of weight saved using aluminum varies from 18¢ to 75¢ per pound. He said there's another way of gaining more payload per dollar invested than by light-metal substitution. That way is to distribute weights on the axles so as to yield greater payload, yet keeping within legal axle load limits.

Basically, the second approach amounts to increasing the load on the kingpin. But that would throw more weight on the tractor rear axle. And that's the one that's critical as regards legal weight limitations on axles.

So to get around this one, White has developed a "pusher" axle with individual wheels mounted to the frame, and placed ahead of the driving axle. These wheels steer in coordination with the front axle. And the pusher axle weighs only 1350 lb, including two 10.00-20 tires.

The drive axle alone is restricted to an 18,000-lb load by law. But the pusher and drive axle combination can carry 27,000 lb. So deducting the dead weight of the pusher, a potential gain of 7650 lb is realized.

Bauman showed how this added weight, or part of it, can be turned into revenue-producing payload. That's because a conventional two-axle tractor and semitrailer seldom can reach the GVW ceiling due to axle weight restrictions. For example, a conventional tractor may have these limitations: 7500 lb on the tractor front axle; 18,000 lb on the tractor rear axle, and 32,000 lb on the trailer rear axle. Total weight that can be loaded on this rig under legal limits on axles is 57,500 lb. Yet the permissible GVW for the rig is 60,000 lb.

With the additional pusher axle, it's now possible to pick up that additional 2500 lb.

This report is based on discussion and six papers presented at the 1952 SAE National Transportation Meeting . . .

Fleet Management; A Job Evaluation
By **T. L. Preble**, Tide Water Associated Oil Co.
Lighter Trucks for Heavy Hauling
By **C. L. Burton and E. P. White**, Aluminum Co. of America
Total Control with Power Hydraulics
By **R. H. Fritzges**, Mack Mfg. Corp.
Rolling Wheels Gather No Skids
By **A. C. Gunsaulus**, Goodyear Aircraft Corp.
Weight Reduction of Power-Driven Highway Vehicles
By **J. N. Bauman**, White Motor Co.
Experimental Bench Testing Techniques for Truck and Bus Components
By **Gil F. Roddewig**, GMC Truck and Coach Division

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.

They are also immediately available in full in multilithographed form from SAE Special Publications Department at 25¢ a copy to SAE members and 50¢ a copy to nonmembers.

Trailer Has to Be Right

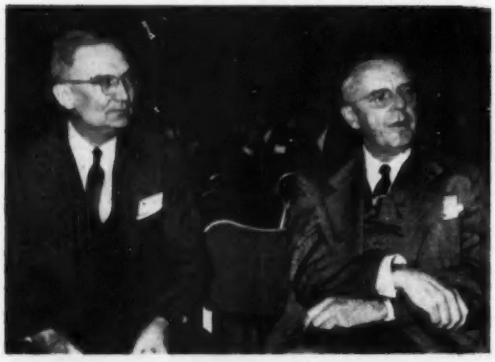
Ward Bennett, of Baltimore Transfer Co., pointed out that trailer design has to be suitable to make use of the pusher axle. Some of his fleet consists of

Gadgets supplemented words and pictures in getting over ideas. At left is a demonstration model of Goodyear's antiskid brake device, which duplicated the operation of the system on a truck. Another crowd-drawer was the display of hydraulic units (at right) shown by Bob Fritzges to demonstrate the equipment he described in his paper on hydraulic control systems for buses

Chairmen and Speakers

Linn Edsall (left) and J. N. Bauman, who urged consideration of weight distribution as a way to increase payload

H. E. Fox (left) was chairman of the session at which Gil Roddewig told about GMC Truck and Coach Division's bench testing techniques



O. A. Brouer (left) and Ted Preble. The fleet management job was evaluated by Preble

Listening to a discusser talk about hydraulic components are session chairman Joe Harvey (left) and Bob Fritzges

J. V. Bassett is asking Goodyear's A. C. Gunsaulus about the new skid-stopper for truck wheels which Gunsaulus described

Fred Lautzenhiser (left) chairmanned the spirited session at which Alcoa's E. F. White (center) and C. L. Burton (right) showed how to cut vehicle weight with aluminum

tandem axle trailers. So it wouldn't be possible to get the weight transfer. Then too, with a normal trailer, if the landing gear is back too far, shifting the weight too far forward in loading would tip the trailer.

Discussers agreed with Bauman that the pusher axle shows promise of payload increase in theory. But what happens in practice, they asked. Orville Brouer said Swift & Co. is putting the unit into service. By next March, he should have data on actual gains.

Advantages with hydraulic power control can now be backed up with experience, said R. H. Fritzges, of Mack Mfg. Corp. With it, a weight and size reduction is possible. For example, Mack can equip a bus with a hydraulic system and save 150 lb, and that takes into account the hydraulic fluid. With power steering, another 90 lb can be saved. And the installation can be made without departing much from the manufacturing methods and techniques used with pneumatic systems.

Bus Man Likes Hydraulics

E. N. "Bing" Hatch claimed power steering is a must for heavy city buses. So he asked, "Why pay for installing and maintaining both the hydraulic pump system and compressor for an air system? If the hydraulic power system provides all the necessary controls, why not use it?"

From an operating standpoint, Hatch likes hydraulic control better too. If the system develops any leaks, you can find them readily. Hatch also ran some tests on New York City coaches and found the hydraulic brake system gave him a good safety margin, even with a broken brake line or diaphragm.

Hydraulic devices as well as other vehicle components can be redesigned to overcome service-proved shortcomings with the help of bench testing. And the testing job needn't be done with elaborate facilities, showed Gil Roddewig, of GMC Truck & Coach. He demonstrated several bench test setups cobbled up virtually with a few pieces of angle iron, some old pulleys, a junked connecting rod, and a piece of cold-rolled steel.

In one set up, a cradle was built to pivot with the actuation coming from an air cylinder. The test rig helped develop better packing crates for military truck parts shipped overseas. The same rig rocked and bumped fuel tanks, simulating the effect of actual service on mounting straps, tank ends, and internal baffles.

Improvised Test Saves Radiator

Frank Kateley, ACF-Brill, told of a cobbled up bench test that once got him out of trouble on a radiator design. The radiator in service leaked consistently at the tubes near the top header tank. With less than $500 worth of equipment, his engineers developed a test rig that proved there was a design weakness in the radiator. He was able to sell the radiator manufacturer on the real cause, showed what remedy could be made based on test results, and eventually got radiators that didn't leak.

Both Roddewig and G. W. Hostetler, International Harvester, warned that bench testing may lead to

. . . Around the Meeting

At the T&B Activity Committee meeting, somebody asked: "Did any of you fellows ever get an order for a standard truck model?" . . . "We did," quipped Mack's M. C. Horine, "and we had to make it a special."

Everybody who came to this Transportation Meeting was interested in listening to the speakers and participating in the technical sessions. The meeting probably set a record in that respect. About 99 44/100% of those registered at the meeting actually attended the technical sessions.

The T&M Activity Committee meeting at one point turned into a first class round-table discussion. Subject: What a fleet manager's function should be, how men should be trained and scholastically educated to be fleet managers. Chief participants were Kay Glynn, Bob Gardner, Bud Gorman, Joe Harvey, Gavin Laurie, Ted Preble, and Emil Gohn.

. . . Divergent views interested the Committee so much, it promptly set up an official Round Table covering this area for the 1953 Summer Meeting at Atlantic City. Its chairman will be Gavin Laurie.

Jack Bassett said he once saw a rubber part submerged in arctic waters actually burn. The part was subjected to so much high-speed vibration, the internal friction developed was enough to carbonize the material.

SAE Pittsburgh Section Chairman K. G. Scantling, General Chairman S. G. Page, and their committees drew raves for their dinner meeting program and general handling of the meeting. Said Emil Gohn of Atlantic Refining, "These fellows set such high standards for this National Transportation Meeting, it's going to take some to match this performance at the next one."

overdesign. If the breakdown is accelerated by test conditions, you may be kidding yourself into a better correction than needed, said Roddewig. Too mild a test procedure may fallaciously show need for little or no design improvement.

The mechanical aspects of vehicle operation will only partly achieve best fleet management results, advised Ted Preble. Relationships with people are equally important. That includes superior officers, drivers and mechanics, and vehicle manufacturers.

Preble saw the fleet job encompassing:

- Equipment selection and retirement based on field job analysis and thorough cost accounting studies.

- Maintenance that brings reliable and economical operation.

- And vehicle operating techniques designed to reduce both out-of-pocket and investment outlay.

Fully achieving these three fleet management aims calls for applying the human relations aspect of the job.

If top management lacks automotive knowledge, the fleet operator can feed him automotive facts of life. Driver morale should be enhanced. That'll help cut accidents, reduce maintenance, and speed up trip time.

Getting the kind of vehicles you want will come only from working with manufacturers and their service men, said F. K. "Kay" Glynn. This type of cooperation can't be haphazard if it's to produce results.

From the Horse's Mouth

Such a program must start with the driver, said Glynn, because he's the first man to sense faults. Next to find what's wrong are the mechanic, foreman, and vehicle superintendent. This type of awareness by fleet men can catch troubles even before factory district offices and dealers.

Get word of these needed improvements through to the manufacturer, said Glynn. They'll appreciate it and do something about it. And then follow through when the improvements are made by telling your foremen, mechanics, and drivers that their observations remedied the ills.

Manufacturers appreciate this thinking, said Merrill Horine. Back in 1914 the chief engineer of Mack insisted on keeping several accounts himself when given the top engineering job. "I can't do a good engineering job unless I'm in touch with the fleet operator," he explained.

Legislators and highway officials are other people with whom the technically-trained fleet man should work. That's another way of getting better operating results. Both "Bud" Gorman, Esso Standard Oil, and Gavin Laurie argued that the fleet man should advise the men who make the laws and design the highways. The engineer should help inject technically sound thinking in both these areas. Otherwise he'll be hampered with needlessly restrictive regulations and inadequate roads.

Around the Meeting . . .

Pennsylvania Chamber of Commerce shared William Penn Hotel's 17th floor with SAE on the Meeting's first day. Eavesdropper at the C of C luncheon heard one speaker recognize the need for brevity with: "The head can't absorb any more than the seat can endure." . . .

. . . Then he defined a good administrator as "one who goes around with a worried look on the faces of his assistants."

Same SAE eavesdropper reported a few Dr. Leo Wolman quotes from the Columbia professor's debate at the C of C with CIO's David J. McDonald about future of collective bargaining. One Wolman point was:

The number of things being bargained about is increasing continuously. That's bad . . . partly because the human mind can't encompass so many details; the bargainers get to fooling with things they are not competent to handle . . . but it's bad chiefly because management must keep the right to operate efficiently.

McDonald, our eavesdropper reported, was definitely against strife and strikes and in favor of cooperation.

Few worked harder at the technical sessions than the secretaries who reported the discussion. They were: Henry Jennings, Fleet Owner; Myles English, National Highway Users Conference; William Howe, Gulf Oil Corp.; R. L. Sailer, Freedom Valvoline Oil Co.; Murray Simkins, Commercial Car Journal; and W. T. Menewisch, GMC Truck and Coach.

Overheard: Feller addressing a snooty audience said, "I expected a few laughs, but all I ever got were intellectual nods and deep breathing."

Service Problems

Featured at F&L Meeting

SPEAKERS at the National Fuels & Lubricants Meeting, held at Tulsa, Nov. 6–7, did no crystal-gazing. They stuck strictly to the here and now, bringing their audience up-to-date information on several problems that have been plaguing users—some of them for a good long time.

There were progress reports on important research projects designed to increase our understanding of the basic mechanism of knock.

Others presented the latest dope on such varied matters as cold-weather operations, lubrication of turbine-powered aircraft, rusting of aircraft engines in storage, and correlation of lubricating oil laboratory engine tests with actual service conditions.

Mechanism of Knock

In trying to unravel the complexities of engine knock, engineers are coming up with some extremely basic information about what goes on inside the combustion chamber. And they have devised several very neat laboratory techniques designed to inveigle the engine into revealing more of its secrets.

H. J. Gibson, C. A. Hall, and D. A. Hirschler of Ethyl showed, for instance, that the lube oil, as well as the fuel and its tel content, influence knock.

They developed their data by means of a single-cylinder laboratory engine test procedure designed to respond to the deposit effects of fuel, oil, and tel in the same relative manner as passenger cars in light-duty service—where requirement increase effects have proved most troublesome. They reported this procedure gave cost and time savings, as well as closer control of variables.

Then there was the account of an unusual laboratory sampling technique developed in England at the Ricardo laboratories.

As described by J. C. Street, Shell Petroleum Co. Ltd., this technique allows the following data to be collected:

1. The steps occurring between the first breakdown of tel and the formation of the final products.
2. The time in the cycle at which various scavengers exert their effect.
3. The types of compounds formed.

Additional data on the effect of precombustion reactions on the tendency of a fuel-air mixture to knock were presented by M. W. Corzilius, D. R. Diggs, and D. L. Pastell of du Pont.

They attempted to isolate the proknock reactions using a motored engine. This technique simplifies the investigation, they said, because compression of the unburned charge by the piston is substituted for compression of the end gas by the flame front.

Their studies covered:

1. Effect of mixture composition changes on cool-flame and autoignition limits.
2. Significance of the time factor in controlling precombustion reactions.

Deposit studies so far have been concerned mainly with the ordinary knock that results from compression of the end gas by a normal, spark-initiated flame front. John Moxey of Sun Oil thought that most of the knock we are getting in actual service is complicated by the occurrence of autoignition—

Midcontinent Section Chairman W. F. Ford (left) talks over dinner arrangements with SAE President D. P. Barnard (center) and Toastmaster John H. Baird

that the deposits are, in most cases, serving as the source of the autoignition. Thus, he concluded, we should look at the combined problem of autoignition and knock, rather than at knock alone.

R. L. Overcash of Kendall suggested that deposits could possibly be minimized by using higher temperatures and pressures in the combustion chamber or by coating the cylinder-head surface and the top of the piston with an insulating material. Hirschler replied that they hadn't been too successful in getting beneficial effects by these means.

The insulating coating did reduce the deposits, he reported, but in return acted like deposits, so there was no net gain.

Corzilius et al pointed out that most hydrocarbons seem to ignite by a two-stage process, the first stage being represented by pre-cool-flame reactions —when oxidation and decomposition products of the fuel start to form—and the second stage by cool-flame reactions. The cool flame is detected by the appearance of faint, visible radiation. This reaction continues, they said, until the temperature and pressure conditions become severe enough to cause the hydrocarbon to ignite spontaneously.

There is plenty of photographic evidence of the two-stage reaction associated with knock, according to C D. Miller, Battelle Memorial Institute. He pointed out, however, that in at least one set of high-speed photographs, a combustion cycle with violent knock showed no evidence of a cool-flame stage.

The data of Corzilius et al seem to indicate that important reactions leading to knock take place during the precombustion stage. "If both precombustion reactions and autoignition are needed for knock," Miller said, "the precombustion reactions must prepare the end gas for autoignition of a particular type, different from the autoignition encountered without precombustion reactions. Could this knocking type of autoignition be the detonation wave shown by the high-speed photographs?"

The Street technique for investigating the mechanism of knock was reported to involve the sampling of peroxids and aldehydes extracted from the end gas of the combustion chamber during the preflame period. The data show, said Street, that the period in the cycle when tel exerted its antiknock action was between tdc and 10 deg atdc. Although it has been generally accepted that when lead exerts its antiknock effect it is present in the form of lead oxid, no free lead oxid was detected in the Street tests.

B. M. Sturgis of du Pont reported, however, that lead oxid did play an important role in their tests. We used to think it was the halids that were important, he continued. Now our work indicates, he said, that the lead oxid forms and then later reacts with the hot gases to form various halids.

Lead oxid, he pointed out, is the only stable lead compound that can exist at the high temperatures of combustion and exhaust strokes. Moreover, from their tests they concluded that the gas phase reactions are probably not very important in determining what sort of deposits are built up in engines.

Cold-Weather Operation

That fuels and lubricants have been developed to the point where they give more satisfactory service under wintertime operating conditions was indicated by several speakers.

Kenneth Boldt, Pure Oil Co., C. S. Bruce, National

Bureau of Standards, and J. G. Moxey, Jr., Sun Oil Co., were coauthors of a paper that discussed the fuel angle, reporting on CRC-Ordnance-sponsored tests with several types of military vehicles.

These tests, which were carried out at Camp Grafton, Devil's Lake, N. D., showed that the present all-purpose grade of gasoline provides adequate warmup performance for most military tactical transport and combat vehicles down to 0 F.

Starting performance at 0 F was another story, however. Several of the wheeled vehicles were rather poor in this regard, although limited tests did indicate that primers would be helpful in some cases. None of the track-laying vehicles gave very satisfactory starting performance at 0 F, even with the use of primers. It was felt, however, that the overall result of the starting tests was somewhat more favorable than might have been expected, in view of World War II experience.

Although the data at –20 F are more limited, because so little of this temperature was experienced, it does appear that both starting and warmup times are satisfactory when arctic-grade fuel is used. Warmup times again were satisfactory for the tracked vehicles, with priming, but starting time was unsatisfactory.

The authors concluded that for vehicles that don't start satisfactorily, even with the use of primers, it would seem logical first to attempt to provide better starting ability by mechanical means before considering the possibility of altering fuel volatility.

Satisfactory lubrication of engines operating in cold climates can be accomplished, it seems, either with the new 5W petroleum oils or with the synthetic oils tailormade especially for this sort of service.

John H. Baird of Lubrizol with the largest item in his collection of "music boxes"—a calliope. Between sessions he entertained the assembled guests with its sweet sounds, playing various oldtime circus and other popular tunes, like the "Gladiators' March" and "Five Feet Two and Eyes of Blue"

F&L Vice-President John Moxey, Jr. (left) congratulates General Chairman Frank A. Suess on the huge success of the largest-ever-held-at-Tulsa F&L meeting

J. A. Miller and H. F. Galindo, Calif. Research Corp., presented the case for synthetics. They said that, used alone, the polypropylene glycols provide not only satisfactory control of low-temperature engine wear and deposits, but they are also very effective in minimizing high-temperature wear—and at oil mileages comparable to those of summer-grade oils, where the 5W petroleum oils have fallen down on the job.

H. C. Mougey of GM pointed out that the new 5W oils are greatly improved in regard to oil consumption. It seems GM is now recommending the new 5W oils for use at –10 F and lower. In addition, Mougey said, they can also be used for occasional winter days when the temperature is above –10 F. In reply, Galindo agreed that the petroleum oils are still very useful, but he asserted that even the best petroleum oil can be improved by blending with synthetics.

Synthetic oils of the polyalkylene glycol types are also being used successfully in passenger cars and commercial vehicles, according to F. A. Gundlach, National Carbon Co.

Synthetics, W. A. Zisman, Naval Research Laboratory, pointed out, have certain inherent advantages over mineral oils. As they are homogeneous in the chemical sense, he said, all of the properties are readily predicted and controlled. Familiar types of chemical addition agents can be used to improve them. Thus, he continued, the development of compounded oils is generally simpler, since there are no undesirable chemicals present to cause variations from one production batch to another in the response to antioxidants, V. I. improvers, detergents, oiliness additives, and wear preventives.

Lubes for Turbine Engines

Another field in which synthetics seem to be coming into their own is to lubricate aircraft turbine engines. In the older designs, the lubricants are not subjected to severe high-temperature conditions, and so can be operated satisfactorily on low-viscosity, low-pour-point mineral oils such as MIL-0-

Listeners of the local television station KOTV learned a few things about the SAE, calliopes, and English television when Perry Ward (third from right) interviewed on his program (left to right) General Chairman Frank A. Suess, Calliope-Owner John H. Baird, and Peter G. Brackley, Alan A. Rawlings, and John J. Withers (the latter three are of the Anglo-Iranian Oil Co.)

6081A grades 1010 and 1005, according to A. B. Cramption, W. W. Gleason, W. E. Lifson, and E. F. H. Pennekamp of the Esso Laboratories.

The newest turbojet and turboprop engines, with their higher compression ratios and increased power output, have, they said, inevitably forced bearing and oil temperatures upward and increased unit loads on gears and bearings. They reported bearing temperatures in excess of 450 F and oil-in temperatures above 225 F are not uncommon. Coupled with this is the U. S. Military requirement for engine starting at -65 F.

In view of the basic shortcomings of petroleum oils as far as meeting these requirements is concerned, the authors' company undertook the development of wholly synthetic oils designed more nearly to fulfill the requirements.

They reported the development of several synthetic oils of the ester type that gave markedly superior performance in both turboprop and turbojet engines, as compared with mineral oils.

Even more improvement is needed with these oils, they continued, in terms of better load-carrying capacity and better high-temperature stability.

The outstanding property of diesters that makes them useful, and which represents the principal deficiency of mineral oils, is, according to V. W. Ware of Rohm and Haas, their extremely low volatility, combined with low viscosity at very low temperatures.

In addition, he said, they have a stability and an ability to lubricate equivalent to that of mineral oil. They are stable to heat and oxidation, and they are difficult to hydrolyze. Furthermore, they dissolve and respond readily to the action of ordinary antioxidants, detergents, bearing corrosion inhibitors, rust preventives, and extreme-pressure agents.

The synthetics do, however, have lower specific heats than the mineral oils, E. A. Droegemueller of Pratt & Whitney reported. Therefore, more of them have to be circulated to get the same coolant effect. Moreover, he cautioned, the oils and their additives must not volatilize at altitudes of 40,000-50,000 ft. Low volatility at high temperatures is important Zisman explained, because evaporation of the oil increases consumption and leaves bearings unlubricated after shutdown. Furthermore, he continued,

Speaker at the dinner, held on Thursday evening, was Cecil M. Hunter of Amarillo, Tex., better known to radio listeners as "Stutterin' Sam."

Called from the audience Hunter got up, said he had nothing to say, and sat down. Finally, he was coaxed to the platform by Toastmaster J. H. Baird. He forced a smile and started—

"Mrs. Chairman . . . I mean Mr. Gentlemen . . . ah, jasdes and lentlemen . . . it feels to me—it gives to me a great feeling—I mean, it's a pleasure to feel . . . that is, it's g-g-good to b-b-be here."

Then for 30 minutes he entertained his audience.

evaporation of the less viscous and more volatile fractions in some oils increases the viscosity of residual oils and thus the power required for cold-weather starts.

Special rust preventive lube oils are proving quite successful in protecting reciprocating aircraft engines from internal rusting. This was the report of E. F. H. Pennekamp, J. D. Oathout, Esso Laboratories, and D. B. McFadden, Humble Oil & Refining Co., who said that such rusting has been a major maintenance problem with engines that are temporarily idle or are stored under high-humidity, high-temperature conditions.

These oils are said to be suitable for both break-in and flyaway service. They incorporate an ashless inhibitor, which, it was reported, overcomes the deficiencies of previous rust preventive compounds or oils of the AN-VV-C-576b type using metallic inhibitors.

Capt. C. M. Murray of the Wright Aeronautical Development Center, said that, although these new oils are approximately four times better than the earlier ones, the Air Force needs still better products. The old ones, he said, were satisfactory for low-power engines, but they are not good enough for the newer high-power models.

The ashless feature of the new oils caused Mel Young of WAC to ask about a procedure to determine when the oil must be changed or additional rust preventive compound added. He said that at Wright they run their engines for 15 min with the rust preventive lube oil, using the oil over and over again. It is simple to test the ash-type oils, he said, by analysis of its ash. Pennekamp replied that a means of analyzing the new oil has been developed to determine its further usefulness. He cautioned, however, that other suppliers will probably have to develop methods of analysis for their products, particularly if the oils are not in the same functional group as theirs.

Correlation of Oil Engine Test Procedures

The best correlation of a test engine with field behavior, or one test engine with another, according to R. Stansfield and J. G. Withers, Anglo-Iranian Oil Co., Ltd., is obtained when all of the following factors are matched:

- Temperatures of the various engine parts.
- Combustion cleanliness.
- Catalytic effect of the metals in contact with the oil.
- Contact time of the oil (a) under conditions of high temperature and (b) with the combustion products.

In regard to temperature, they said that special attention should be given to the following: For piston and cylinder deposits and wear the top piston-ring groove and liner temperatures should be held to values that are equal to those obtained in the field under heavy-duty conditions. For bearing corrosion, they said the crankpin temperatures should be held to the best estimate of the highest possible service value.

If copper catalysis is a factor in the field, they said that a copper sheet should be introduced into the oil system and all pipes and fittings should be made of noncatalytic material. It is important, they added, that the sheet be easy to clean by chemical means and be renewed from test to test.

In discussion, both K. Boldt, Pure Oil Co., and C. G. A. Rosen, Caterpillar Tractor Co., suggested that the material in this paper should prove helpful to the CRC-CLR group that is studying the development of a lube oil test engine.

Boldt also presented data to show that better correlation can be obtained with the FL-2 test procedure when special efforts are made to keep cylinder-wall temperatures the same for all cylinders.

Session chairmen, whose leadership of the sessions helped to make the meeting a success, were:
R. C. Alden, Phillips Petroleum Co.
N. C. Penfold, Southwest Research Institute
J. R. Sabina, E. I. du Pont de Nemours & Co., Inc.
W. F. Ford, Continental Oil Co.

Session secretaries, whose reports helped to make SAE Journal coverage of the meeting more complete, were:
D. B. Wimmer, Phillips Petroleum Co.
J. W. Vollentine, Caterpillar Tractor Co.
M. D. Lawson, E. I. du Pont de Nemours & Co., Inc.
C. A. Hall, Ethyl Corp.

This SAE Journal story is based on the following papers (and discussion), which were presented at the FOL Meeting:

"Combustion-Chamber Deposition and Knock," by **H. J. Gibson, C. A. Hall**, and **D. A. Hirschler**, Ethyl Corp.

"Some Factors Affecting Precombustion Reactions in Engines," by **M. W. Corzilius, D. R. Diggs**, and **D. L. Pastell**, E. I. du Pont de Nemours & Co., Inc.

"Correlation of Lubricating Oil Engine Test Procedures," by **R. Stansfield** and **J. G. Withers**, Anglo-Iranian Oil Co., Ltd.

"Development of Rust Preventive Lubricating Oils for Reciprocating Aircraft Engines," by **E. F. H. Pennekamp** and **J. D. Oathout**, Esso Laboratories, and **D. B. McFadden**, Humble Oil & Refining Co.

"Engineering Possibilities of Synthetic Lubricants," by **W. A. Zisman**, Naval Research Laboratory.

"Diesters and Properties which Make Them Useful as Specialty Lubricants," by **V. W. Ware**, Rohm & Haas Co.

"Performance of Turbo Engine Synthetic Oils," by **A. B. Crampton, W. W. Gleason, W. E. Lifson**, and **E. F. H. Pennekamp**, Esso Laboratories.

"Case for Synthetic Lubricants in Winter Operation of Automotive Engines," by **J. A. Miller** and **H. F. Galindo**, Calif. Research Corp.

"Mode of Formation of Lead Deposits in Gasoline Engines," by **J. C. Street**, Shell Petroleum Co. Ltd.

"Volatility Studies of Military Vehicles, Covering CRC-Ordnance 1951-1952 Devil's Lake Work," by **Kenneth Boldt**, Pure Oil Co., **C. S. Bruce**, National Bureau of Standards, and **J. G. Moxey, Jr.**, Sun Oil Co.

These papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Transactions.

These papers are also immediately available in multilithographed form from SAE Special Publications Department at 25¢ a copy to SAE members and 50¢ a copy to nonmembers.

Installing Turbojet Presents Cooling and Vibration Problems

Frank B. Lary, Curtiss-Wright Corp.

Based on paper, "Installation Problems of the Turbo Jet," presented at Joint IAS-SAE Philadelphia Section Meeting, Dec. 5, 1951.

THERE is no complete answer to the question of whether we should have a universal engine or engines designed to suit each installation. However, there is a conclusion. In its development stage an engine should be flexible (or universal) in its provision for accessories and other installation items so that it can be studied in several types of aircraft. Then an optimum configuration might be obtained and frozen for one particular installation to be made in some quantity. Large quantities would make worth while added effort to obtain maximum performance and minimum weight.

The cooling problem is becoming worse year by year. The higher the design Mach number the greater the total temperature and, therefore, the lower the temperature difference between limits on various engine units and the cooling air. In fact, the air will be so hot it can hardly be considered cooling air at speeds not too far over the horizon.

A solution to this problem lies in several different sources. First, the item may be cooled below air total temperature by refrigeration, which is very undesirable, or by using the great thermal reservoir of fuel. Second, we may have to reduce requirements by improving materials and raising the limits such as by changing from rubber to silicone. Third, we might schedule flight at various altitudes to avoid high-speed operation at sea level where the air is hot, providing this is in keeping with plane use.

The suspension system, or mount, of the turbojet is fundamentally simple. However, the mounts transmit vibration, such as it is, from the engine or the propulsion unit to the craft structure. Data reached by averaging the findings of several investigators (Fig. 1) show that the human can stand a large amplitude at the frequencies emanating from the piston and propeller airplane, which is in the order of 10 to 20 cps. At frequencies coming from the turbojet, as high as 100 to 150 cps, the tolerance of the human is much less. Even though the amplitudes coming from the engine are within reason, they still may exceed, at the engine, the values that the human body can tolerate.

The problem of isolating all modes of vibration from the pilot is being considered. Rubber mounting units have been tested to some extent and are being evaluated. Rubber can be applied in a compact manner to reduce the natural frequencies of the suspension system when they are at a high value of 3000 to 4000 cpm at the start. It should be remembered, however, that the attachment of rubber, or even silicone, to the center of a turbojet engine introduces complications to cooling as the engine is hot in this vicinity.

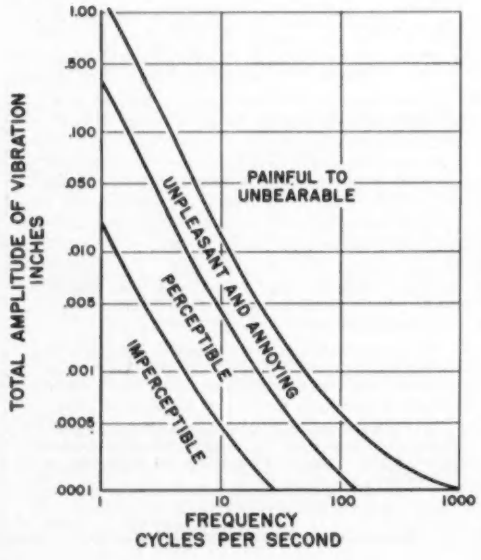


Fig. 1 — The human body's sensitiveness to vibrations of various amplitudes and frequencies such as are experienced by pilots of modern planes

Traffic Congestion Hurting Bus Operators

Based on paper by

LEON F. BANIGAN

Editor, Bus Transportation

BUS transportation is suffering severely from the backwash of the explosion of our cities caused by motor vehicles. Everybody who moved to the suburbs to live or to start a business appears to want to drive his car back into the cities and park it in the streets. To bus transportation it means loss in revenue from the millions of suburbanites who drive to town daily; it also means greatly increased costs of operation due to snarled traffic and slowed schedules.

Transit bus operators counting heads in private cars in city traffic have found the ratio to be about 1½ persons per car. An average city bus could carry the load of 40 cars without crowding and at an enormous saving in street space. These operators would like to know how much worse traffic jams can get before the suburbanite decides it's smarter and cheaper to leave his car in the garage and use interurban and transit buses. (Paper, "How Buses Have Affected Passenger Transportation," was presented at the Centennial of Engineering, Chicago, Sept. 8, 1952.

NEWS OF SAE

pages 81—96

SHOW AND TELL . . .

. . . techniques to communicate provocative ideas at Annual Meeting in Detroit next month.

ENGINEERS attending the SAE 1953 Annual Meeting will take away with them fresh automotive engineering facts dished up in many ways.

- They'll be told about these facts by 36 speakers.
- They'll be able to "talk with" experts at eight panel sessions and symposiums.
- They'll be shown by a live TV program, demonstrations, and displays.

In the passenger car area, the program is alive with news value and interest. Buick's new V-8 engine heads the parade of new design disclosures. Maurice Olley, until recently with Vauxhall in England and now with Chevrolet, will evaluate European postwar cars.

The Production Activity offers a crystal-ball look at the future of atomic energy in industry. W. L. Cisler, president of Detroit-Edison, will do the forecasting. Also on the predictive side will by Dr. D. G. Samaras' evaluation of new energy sources for aircraft propulsion . . . magnesium, aluminum, nuclear fission, and perhaps the mercury vapor cycle. Dr. Samaras is from Wright Air Development Center.

Reports from researchers will open new vistas for designers. J. D. McCullough, of Ethyl Corp., will reveal data on combustion chamber pressure measurements, with an insight into the combustion process. Three scientists from Standard Oil Development have word on a laboratory engine test for low temperature sludging. R. F. Winch and F. M. Mayes of Sun Oil are to disclose a new method of identifying preignition.

The eight panels and symposiums bring to Annual Meeting varied viewpoints on controversial and timely subjects. They also offer greater opportunity for audience participation. These sessions offer juicy morsels in wide areas of automotive and aeronautic interest. Here's what they'll cover:

- **Titanium**—its production, properties, uses, and fabrication.
- **Wear and Surface Treatments**—coatings for ferrous, aluminum, and magnesium surfaces and the role of lubricants.
- **Helicopter Engines** — performance characteristics they should have, considerations for a gas turbine, and fitting the piston engine to the 'copter.
- **Fleet Repairs** — pros and cons of fleet-owned shop versus factory branch and dealer shops.
- **Synthetic Oils** — a question-and-answer forum on their use in aircraft gas turbines.
- **Turbine-Powered Transports** — what's in store for operators who'll fly them.
- **Nodular Iron**—how can it be put to work in tractors and other automotive equipment.
- **Fibre Glass**—what's its future in automotive bodies, how is it processed, what plastics can be used.

Visual presentations also will play a big part in disclosing engineering facts to those at the meeting. A theatre-size television screen will bring a live demonstration of Timken's new axle testing lab to the audience at the Rackham Educational Memorial Building. (See SAE Journal, October, 1952, page 92.) The session on laminated plastic and fibre glass for bodies will feature a demonstration on how parts are made from these materials.

At the engineering display at the Annual Meeting some 50 manufacturers will exhibit currently used automotive parts and equipment.

FIRST . . .

. . . is the word for Ben Moreell, who speaks at SAE 1953 Annual Meeting Dinner.

THE word "first" keeps popping up in biographical sketches of Ben Moreell, who will be the speaker at SAE's 1953 Annual Meeting Dinner in Detroit next January 14. The ex-Vice-Admiral who is now Jones & Laughlin's board chairman has blazed many new trails.

He was the first officer not a graduate of Annapolis to hold the four-star rank of admiral in the U. S. Navy . . . and he was the first Staff Corps officer of the Navy to hold that rank. Made a vice-admiral at 51, he was the youngest man ever to hold the rank.

He was the first head of the Navy Seabees, which he organized during World War II. He led it from a start of 3300 men to an organization of over 10,000 officers and 240,000 men—more than three-quarters of whom were active overseas at the end of the war. (This Navy Construction Battalion, construction men who were trained in combat, replaced the pre-Pearl Harbor civilian construction workers employed by the Navy. Their fate at Wake, Guam, and Cavite strengthened Admiral Moreell's conviction that the Navy needed men who could both build and fight.)

Moreell is a civil engineer (Washington University of St. Louis '13) who joined the Navy in 1917, took a competitive examination for his commission. He rose to become chief of the Bureau of Yards and Docks—and later coordinated all materiel procurement for the Navy as chief of the Materiel Division of the Office of the Assistant Secretary of the Navy.

He was also the first Navy officer to be in charge of running the bituminous coal mines of the United States. He was saddled with that task when the government took over the mines in May, 1946.

He left the Navy in 1946, became president and board chairman of J&L in 1947. Last January he relinquished the presidency, remains as chairman of the board and chief administrative officer.

He has been awarded the Distinguished Service Medal, the Legion of Merit, and the Gold Star in lieu of a second Distinguished Service Medal.

When he speaks to SAE, non-Annapolis ex-Navy man Moreell will be on the program with Master of Ceremonies A. T. Colwell, a West Pointer.

Ben Moreell

Questions . . .

. . . on synthetic lubes for gas turbines are solicited for Annual Meeting forum.

IF YOU have questions on the new synthetic lubricants for aircraft gas turbines, you are invited to mail them to

Frank E. Carroll, Jr.
United Aircraft Products, Inc.
1116 Bolander Ave.
Dayton, Ohio

and come to the Aircraft Powerplant Activity's afternoon session on Wednesday, Jan. 14 to get the answers from a panel of specialists on the subject. The meeting will take place at the Sheraton-Cadillac Hotel as part of the SAE Annual Meeting being held there Jan. 12-16.

Chances are you do have such questions if you are a ground vehicle manufacturer struggling to build and test the latest engines dreamed up by the aircraft powerplant manufacturers. Some of the new synthetics compounded for heat resistance and low-temperature pumpability tend to corrode weighing tanks and eat away rubber hoses in production-test facilities. Carroll doesn't claim to have the answers to all such problems, but he and his panel members promise to do the best they can to help. The panel members are

Stephen Drabek, General Electric Co. Aircraft Gas Turbine Division
M. C. Hardin, Allison Engine Division of GMC
E. L. Margolis, Wright Air Development Center
H. A. Murray, The Texas Co.
E. F. H. Pennekamp, Standard Oil Development Co.
M. H. Young, Wright Aeronautical Division

Plans for the question-and-answer forum on Synthetic Oils for Aircraft Gas Turbines were laid during a meeting at SAE headquarters on Oct. 16. Shown conferring on the forum are E. F. H. Pennekamp of Esso Laboratories, Stephen Drabek of GE's Aircraft Gas Turbine Division, Forum Chairman Frank E. Carroll, Jr. of United Aircraft Products, Richard Blair of Wright Aeronautical representing M. H. Young of Wright, and H. A. Murray of The Texas Co.

In case you missed the four-paper Symposium on Synthetic Lubricants held Nov. 7 at the SAE National Fuels and Lubricants Meeting in Tulsa, these men can tell you why conventional petroleum lubricants are inadequate for the powerful new turbine engines and what special properties of synthetics justify their use in spite of cost and handling difficulties.

Planners of New York Production Forum

THE SAE Aeronautic Production Forum scheduled for April 20, 1953, in New York, is fairly well lined up. According to a report from General Chairman Michael Field and his executive committee (above), nine panel subjects have been selected and invitations are now out to panel members and leaders.

The Committee surveyed production men in aeronautic companies in the East to find problems most pressing in day-to-day plant operations. Reports from industry led to selection of panel subjects on production procurement, machining, titanium, large castings and forgings, production management, and jet engine blade and bucket manufacture.

Men from companies big and small will serve on the panels. Invitations are out to production specialists from more than 40 individual companies, advises Chairman Field.

Forum Sponsor Roy T. Hurley, Curtiss-Wright Corp., has notified more than 250 top executives of aeronautic, automotive, and supplier companies of the Forum. Participation also is being invited from plants of vendors and subcontractors, and the Air Force and Navy Bureau of Aeronautics.

Members of the Executive Committee are (above, left to right): Emil Gibian, Thompson Products; Henry Fischbeck, Pratt & Whitney; Herman Hanink, Wright Aeronautical; Alfred Hegner, Fairchild Engine; Chairman Field, Metcut Research Associates; Joseph Andreini, Republic Aviation; George Evans, Sperry Gyroscope; Philip DeHuff, Westinghouse Aircraft Gas Turbine Division; and Ed Kemble, General Electric.

YOU'LL . . .

. . . be interested to know about these SAE news events

SAE Special Publications Department is starting a new service for members. Reports of all SAE Production Forums will be published and made available. The first of these reports to be issued, and it'll be ready soon, is on the SAE Aircraft Production Forum at Los Angeles, on Oct. 1. Its price will be $2.00. The SAE Journal will continue to publish reports of all Production Forum panels.

* * *

Society membership hit a new all-time high at the end of the 1951-52 fiscal year. As of Sept. 30, there were 17,112 dues-paying members in SAE. Also during that period 2436 applications for membership were received.

* * *

The television session at SAE Annual Meeting, on the evening of January 12, keyed to the paper "How a Proving Ground Was Moved Indoors," will boast a number of "firsts."

- First national engineering society meeting using live television.
- First technical meeting session at which discussion will be carried on between participants over a seven-mile distance.
- First electronic type, automatic cycling dynamometer will be described and demonstrated at this session.

* * *

SAE Readers Committees will be expanded to include junior members of the Society, reports T. B. Rendel, chairman of the Publications Committee. Aim is to reflect the desires of younger members of the Society in technical material published in SAE Transactions and SAE Journal. (These Readers Committees advise the editors of the two publications on the handling of each paper presented before the Society.)

National Meetings . . .

Meeting	Date	Hotel
	1953	
ANNUAL MEETING and ENGINEERING DISPLAY	Jan. 12-16	The Sheraton-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 3-5	The Sheraton-Cadillac, Detroit
PRODUCTION	March 25-27	Hotel Statler, Cleveland
AERONAUTIC and AIRCRAFT ENGINEERING DISPLAY and AIRCRAFT PRODUCTION FORUM	April 20-24	Hotel Governor Clinton, New York City
SUMMER	June 7-12	The Ambassador and Ritz-Carlton, Atlantic City, N. J.
INTERNATIONAL WEST COAST	Aug. 17-19	Georgia Hotel, Vancouver, B. C.
TRACTOR and PRODUCTION FORUM	Sept. 14-17	Hotel Schroeder, Milwaukee
AERONAUTIC and AIRCRAFT ENGINEERING DISPLAY and AIRCRAFT PRODUCTION FORUM	Sept. 29-Oct. 3	Hotel Statler, Los Angeles
INTERNATIONAL PRODUCTION	Oct. 29-30	Royal York Hotel, Toronto
TRANSPORTATION	Nov. 2-4	Conrad Hilton, Chicago
DIESEL ENGINE	Nov. 3-4	Conrad Hilton, Chicago
FUELS & LUBRICANTS	Nov. 5-6	Conrad Hilton, Chicago

CHANGE . . .

. . . of name may be sought by Diesel Engine Activity. Subcommittee appointed.

THE Diesel Engine Activity may be asking the SAE Council to change its name one of these days. Meeting at St. Louis on October 30, the Activity talked at length about the possibility of including in its scope at least ground vehicle gas turbines.

The growing importance of the gas turbine for ground vehicles was urged as favoring the change.

Discussion ended with the appointment of a subcommittee charged with bringing back to the Activity a recommendation as to whether or not a change of name is desirable. Chairman of the subcommittee is J. W. Pennington of Koppers Co., incoming vice-president of the Activity.

INJECTION . . .

. . . pump of an unusual design is to be featured at AM diesel session.

THE story of an injection pump that has been 10 years in the making is being scheduled as one of the features of the two 1953 Annual Meeting sessions planned by the Diesel Engine Activity. Designated as the Roosa-Master pump, it is said to have only one-tenth as many parts as most commonly used pumps. It has no bearings and only one spring, which is used on the governor . . . Vernon Roosa, one of the designers of the unit, will present the paper. He is connected with the Hartford Machine Screw Co.

Other Diesel-Activity-sponsored papers at the 1953 Annual Meeting will treat of the development of the GM 51 diesel, of combustion-chamber pressure measurements, and of dynamic testing of the GM unit injector.

Diesel vice-president Walter Ainsley, Sinclair Oil Co., will be chairman of the Thursday, January 15 morning session and J. W. Pennington of Koppers Co. will preside at the afternoon session.

25 Years Ago

Facts and Opinions from SAE Journal of December, 1927

The highest paid—and the worst—orchestra in the world played dance music for the 540 members and guests at the Nov. 7 meeting of the Detroit Section. Composed of seven members of the Section, the Detroit High Hat Orchestra proved to be fine automotive engineers.

■

Work of the SAE Operation and Maintenance Committee to date serves to emphasize the lack of any broad, organized effort to improve the large-scale operation of motor vehicles. The committee is moving through practically virgin territory, doing things that have never been done before.

■

Design and construction of front fenders on motorcoaches should receive more attention. Ability to sell rides is determined largely by the confidence a rider has in a coach. And the sight of flapping fenders on approaching coaches is not conducive to confidence in either the vehicle or the operating company.—K. J. Ammerman, American Car & Foundry Motors Co., in Transportation Meeting paper.

■

The time-honored debate on monoplane versus biplane for transport service still rages. English designers favor biplanes almost exclusively; in France, one type seems to be as much in favor as the other; in Germany the monoplane seems to predominate. Aerodynamically, there is little to choose between the two, provided the biplane is properly designed.—C. N. Monteith, Boeing Airplane Co., in Aeronautic Meeting paper.

■

Few problems in the industrial world in recent years have attracted so much attention as the application of finishing materials by the spray method. No other problem has developed so many diversified opinions, many of which are based on personal conclusions without sufficient knowledge of facts.—H. L. Miner, E. I. du Pont de Nemours & Co., in Production Meeting paper.

■

The ever-increasing demand for more passenger-carrying capacity tends to make engineers design motorcoaches with excessive rear overhang. It behooves motorcoach designers to curb this tendency, since excessive overhang increases wear on rear tires and makes turning difficult.—K. J. Ammerman, American Car & Foundry Motors Co., in Transportation Meeting paper.

■

Greater precision will soon be required in the manufacture of parts other than cylinder barrels of internal combustion engines. Grinder manufacturers must be prepared to help car manufacturers in their efforts to meet the never-ceasing demand of the public for better cars.—M. C. Hutto, Hutto Engineering Co., in Production Meeting paper.

■

"If executives continue to demand lower passenger-car bodies, chassis engineers will have to come up with a practical method of reducing frame kickup and the size of the rear-axle housing," asserted Pierce-Arrow's A. F. Carlson at a meeting of the Buffalo Section.

■

If all kinds of transport do not hang together, they may not all hang separately, but certainly some of them will. The experience of military transport in the World War has proved conclusively that coordination of transport is not only practicable, economical, and efficient, but that it is inevitable. —Brigadier-General F. H. Pope, U.S.A., in Transportation Meeting paper.

Program for

1953 SAE Annual Meeting

The Sheraton-Cadillac Hotel

Detroit, Mich.

January 12-16, 1953

Monday, January 12

NOTE: Monday morning sessions open at 10:00 a.m.

All other morning sessions start at 9:30 a.m.

10:00 a.m. Grand Ballroom

Chairman—H. O. MATHEWS, Armour and Co.
Secretary—HENRY JENNINGS, Fleet Owner

Fast Replacement or Heavy Maintenance
C. C. HUDSON, Tennessee Valley Authority

High job shop overhead makes unit replacement of accessories, early replacement of commercial vehicle, economically inviting—except for large, special trucks. Proposed is mass-production overhaul of components on the basis of 100,000 yearly.

(Sponsored by Transportation and Maintenance Activity)

10:00 a.m. Crystal Room

Chairman—C. F. KRAMER, Ford Motor Co.
Secretary—R. A. TERRY, Creative Industries of Detroit

Some Factors Concerning Bodies and Related Components for Commercial Vehicles
E. P. LAMB, Chrysler Corp.

Detroit, it appears, is more concerned than Hollywood with "The Body". Words and pin-ups reveal thinking of owners, drivers, and public about truck bodies and equipment.

(Sponsored by Body Activity)

2:00 p.m. Grand Ballroom

Chairman—ROBERT GARDNER, Lever Brothers, Inc.

Secretary—HENRY JENNINGS, Fleet Owner
Business Session of Transportation and Maintenance Activity

Symposium—An Engineering Approach to Service Problems

Why Use Dealer Shops? (Including discussion of time studies, tools, and facilities)
C. T. DOMAN, Ford Motor Co.

Preventive Maintenance, Repairs, and Cost Controls for a Scattered Fleet
W. H. LANGSEDER, Thomas J. Lipton, Inc.

How Factory Training and Service Publications Provide Advantages in Use of Factory Branches and Dealer Shops
W. W. EDWARDS, GMC Truck & Coach Division

What Are the Advantages of a Fleet Operating Its Own Shops and Having Traveling Inspectors?
R. W. THOMAS, Quality Bakers of America Cooperative, Inc.

Advantages for a Fleet in Purchasing Guaranteed Maintenance
F. G. ALLEN, White Motor Co.

From Truck Driver to Truck Design Engineer
F. K. GLYNN, American Telephone and Telegraph Co.

(Sponsored by Transportation and Maintenance Activity)

2:00 p.m. Crystal Room

Chairman—H. C. SMITH, Great Lakes Steel Corp.
Secretary—WALTER MINCHO, Great Lakes Steel Corp.

Coating Steel by the Aldip Process
D. K. HANINK and A. L. BOEGEHOLD, General Motors Corp.

All about the new hot dip process for coating steel with aluminum. "Aldip" applications promise to aid in conserving stainless steel and higher alloys, to save nickel and chromium in parts and assemblies.

A New Test for Drawability of Sheet Steel
C. B. BUKER and J. R. SPEER, Jones and Laughlin Steel Corp.

Right from the inventor's mouth, all about a newly-patented test instrument which bares the secrets of sheet steel—on the job without sampling or material destruction.

(Sponsored by Engineering Materials Activity)

8:00 p.m. Main Auditorium

Horace H. Rackham Educational Memorial, 100 Farnsworth

The First Live T-V Presentation of a Technical Program at a National Engineering Convention

Chairman—F. W. KATELEY, ACF-Brill Motors Co.
Secretary—W. J. LOCKE, The Timken-Detroit Axle Co.

How a Proving Ground Was Moved Indoors
L. W. FISCHER, The Timken-Detroit Axle Co.

R. W. ROUSH, The Timken-Detroit Axle Co.
E. B. STAVELY, JR., General Electric Co.

Motion Picture — "Testing Military Motor Trucks on an Outdoor Proving Ground at Camp Bullis, Texas"

Live television will bring a demonstration of Timken's new laboratory to the audience. This axle testing equipment simulates the conditions an axle would meet up with on a vehicle operating in service or on an outdoor proving ground. Question and answer period will be conducted by two-way television circuit between the audience at the Rackham Memorial Building and technicians at the Timken-Detroit Laboratories.

Special bus transportation between The Sheraton-Cadillac and the Rackham will be provided.

(Sponsored by Truck and Bus Activity)

Tuesday, January 13

9:30 a.m. **Grand Ballroom**

Chairman—P. S. LANE, Muskegon Piston Ring Co.
Secretary—E. B. ETCHELLS, Chevrolet Motor Division, GMC
Business Session of Engineering Materials Activity

Symposium—Wear and Surface Treatments to Prevent Wear

The Mechanism of Wear
W. E. JOMINY, Chrysler Corp.

Wear Resistant Coatings for Ferrous Metals
R. H. BANCROFT, Perfect Circle Corp.

Aluminum Finishes That Resist Wear and Erosion
R. V. VANDEN BERG, Aluminum Co. of America

Wear Characteristics of Magnesium
E. L. SCHAPER, Dow Chemical Co.

Lubricants—The Surface Savers
J. F. KUNC, JR., and J. P. HAMER, Esso Laboratories, Standard Oil Development Co.

Metals and coatings variously improve surface wear characteristics. Chemical dips, electro-plating, organic finishes, metal sprays, anodic coating, and additive oils are among current techniques. This symposium develops data on relative efficacies.

(Sponsored by Engineering Materials Activity)

9:30 a.m. **Crystal Room**

Chairman—N. R. BROWNYER, The Timken-Detroit Axle Co.
Secretary—W. S. RIGBY, Wagner Electric Corp.
Business Session of Truck and Bus Activity

Construction and Operation of Brake Testing Dynamometers—

Report of SAE Brake Subcommittee No. 3
To be presented by R. K. SUPER, Chairman of Committee

Concise, consolidated report on using inertia dynamometers to evaluate vehicle brakes, with data on design features, instrumentation, and correlation with road tests.

(Sponsored by Truck and Bus Activity)

2:00 p.m. **Grand Ballroom**

Chairman—J. W. GREIG, Woodall Industries, Inc.
Secretary—ROBERT ANDERSON, Chrysler Corp.
Business Session of Body Activity

Fiber-Glass—What It Has to Do with Bodies

Will Glass-Reinforced Plastics Replace Metal in Automobile Construction? If So, When and Where?
GAMES SLAYTER, Owens-Corning Fiberglas Corp.

Problems, Production, and Technique of Laminated Fiberglas
I. M. SCOTT, President, Winner Manufacturing Co., Inc.

The Cement of Reinforced Plastics for the Automotive Industry
EARL EBERS, Naugatuck Chemicals Division, U. S. Rubber Co.

Successful application of glass, plastic, and laminations demands precise knowledge of manufacture and processing, plus design consideration of properties. New art offers not merely substitutions, but newly-created materials and parts. A panel of reference on resins will be on hand to answer questions. New Products from a New Material—an exhibit of fiber-glass products of interest to the automotive industry.

(Sponsored by Body Activity)

2:00 p.m. **Crystal Room**

Chairman—C. A. HUBERT, International Harvester Co.
Secretary—L. S. PFOST, Massey-Harris Co.
Business Session of Tractor and Farm Machinery Activity

Contemporary European Air-Cooled Diesel Engine Practice
W. H. WORTHINGTON, John Deere Waterloo Tractor Works, Deere Manufacturing Co.

The Volkswagen and German Air-Cooled Engine Developments
BOEHNER and DUMPERT, Volkswagenwerk, GMBH

To be presented by S. C. HETH, J. I. Case Co.

Symposium—Application of Nodular Iron to Tractors and Other Automotive Equipment

Nodular Iron in Tractor Motors
H. L. DAY, Auto Specialties Manufacturing Co.

Irons With Spheroidal Graphite
R. W. MASON, JR., formerly with National Farm Machinery Cooperative, Inc.

Ductile Iron as an Engineering Material
B. L. STOTT, State Foundry

Suppliers view as their job the practical application of materials such as nodular iron. From shops, tests, and field they accumulate basic data and experience enriching empirical approaches to evaluating use in farm implements.

(Sponsored by Tractor and Farm Machinery Activity)

8:00 p.m. **Grand Ballroom**

BUSINESS SESSION
President D. P. BARNARD in the Chair

Nomination and Election of Members-at-large of Annual Nominating Committee
Presentation of Proposed Amendments to SAE Constitution
Announcement of Election of Officers for 1953
Presentation of the Annual Report
Presentation of Life Membership

8:15 p.m. **Grand Ballroom**

Chairman—L. I. WOOLSON, President, De Soto Division, Chrysler Corp.
Secretary—C. J. VAN HALTEREN, De Soto Division, Chrysler Corp.
Business Session of Production Activity

The Future of Atomic Energy in Industry
W. L. CISLER, President and General Manager, The Detroit-Edison Co.

Participation of private industry in atomic energy development is essential to getting full benefits. Dow Chemical and Detroit-Edison are working on project for reactor generating electric power. Other atomic developments can affect aviation, marine transportation, and metallurgy.

(Sponsored by Production Activity)

Wednesday, January 14

9:30 a.m. **Grand Ballroom**

Chairman—E. N. COLE, Chevrolet Motor Division, GMC
Secretary—W. R. MACKENZIE, Chevrolet Motor Division, GMC

European Post-War Cars
MAURICE OLLEY, Chevrolet Motor Division, GMC

Should "hot-rods" be taken seriously? Are sports cars making motoring fun? This review of trends abroad indicates that foreign manufacturers are building cars for world markets, American cars are being built for highways now limited to portions of North America!

(Sponsored by Passenger Car Activity)

9:30 a.m. **Crystal Room**

Chairman—F. N. PIASECKI, Chairman of the Board, Piasecki Helicopter Corp.

Symposium—Helicopter and Helicopter Powerplants

Matching the Characteristics of Helicopters and Shaft Turbines
D. M. MEYERS and Z. M. CIOLKOSZ, Piasecki Helicopter Corp.

Helicopter Power Requirements Necessitate Tight Limits on Engine Power Controls
R. W. BRADHAM and J. S. KERR,

Continued on next page

Program for

1953 SAE Annual Meeting

(continued from preceding page)

Bell Aircraft Corp.

The Selection and Evaluation of Powerplants for Helicopters
E. F. KATZENBERGER, Sikorsky Aircraft Division, United Aircraft Corp.

The Reciprocating Engine in the Helicopter
J. J. SHIELDS and J. T. BOWLING, Continental Aviation and Engineering Corp.

Design Considerations for a Helicopter Gas Turbine Powerplant
J. L. KOETTING, Solar Aircraft Co.

Characteristics of the Two-Shaft Gas Turbine in Helicopters
W. B. ANDERSON, Boeing Airplane Co.

Future helicopter powerplants—piston engines or gas turbines? If turbines, single-shaft or double? What of throttle-pitch and rotor controls—manual, mechanical, servo, or combinations? Discussion develops problems, solutions, and opinions.

(Sponsored by Aircraft Powerplant Activity)

2:00 p.m. Grand Ballroom

Chairman—J. B. MACAULEY, JR., Ethyl Corp.
Secretary—H. A. TOULMIN, Ethyl Corp.
Business Session of Passenger Car Activity

New Buick V-8 Engine
V. P. MATHEWS and J. D. TURLAY, Buick Motor Division, GMC

(Sponsored by Passenger Car Activity)

2:00 p.m. Crystal Room

Chairman—F. E. CARROLL, JR., United Aircraft Products, Inc.
Secretary—R. I. CROSS, United Aircraft Products, Inc.
Business Session of Aircraft Powerplant Activity

The Dawn of Aviation's New Era
D. G. SAMARAS, Wright Air Development Center

Calling all space men! Terrestrial and space aviation are demanding new thermal propulsion systems, both chemical and nuclear, which put travel and fuel requirements ahead of engine and airframe. Here's the beginning of a new working philosophy of aircraft design for the outer spaces.

Question and Answer Forum—Synthetic Oils for Aircraft Gas Turbines
Panel of Experts

STEPHEN DRABEK, Aircraft Gas Turbine Division, General Electric Co.
M. C. HARDIN, Allison Division, General Motors Corp.
E. L. MARGOLIN, Wright Air Development Center
H. A. MURRAY, The Texas Co.
E. F. H. PENNEKAMP, Esso Laboratories, Standard Oil Development Co.
M. H. YOUNG, Wright Aeronautical Division, Curtiss-Wright Corp.

Mail your questions in advance to
F. E. Carroll, Jr., United Aircraft Products, Inc.
1116 Bolander Avenue, Dayton, Ohio
and come to hear the answers from the specialists at this session.

To be presented by title:

Automatic Control Systems Satisfying Certain General Criteria on Transient Behavior
A. S. BOKSENBOM and R. HOOK, NACA Lewis Laboratory

Design of automatic controls for gas turbines starts with arbitrary criterions on the behavior of the controlled system and produces physically realizable equations. Criterions include time intervals, facilitating consideration both of linear and non-linear aspects.

Friction Properties of Synthetic Lubricants Suitable for Aircraft Turbine Engines
R. L. JOHNSON, M. SWIKERT, and E. E. BISSON, NACA Lewis Laboratory

Laboratory studies of surface frictions reveal film strength, lubricating qualities, and other characteristics of synthetic oils. Research anticipates lubrication over that broad temperature range of aircraft turbine engines which taxes capabilities of straight petroleum oils.

(Sponsored by Aircraft Powerplant Activity)

DINNER

Wednesday, January 14

Detroit Masonic Temple
500 Temple Street

6:30 p.m. DINNER
Fountain, Crystal, and Panel Rooms

8:15 p.m. SPEAKING PROGRAM
Large Auditorium

STUDEBAKER MALE CHORUS
Ethel Stuart Gaumer, Director
Virginia Stuart, Soloist
Barbara Buettell, Soloist Accompanist

P. H. PRETZ,
Chairman, SAE Detroit Section

Master of Ceremonies
A. T. COLWELL, Vice President, Thompson Products, Inc.

D. P. BARNARD, 1952 SAE President

ROBERT CASS,
1953 SAE Presidential Nominee

C. E. WILSON, President, General Motors Corp.

"The Limits to Engineering"
ADMIRAL BEN MOREELL
Chairman of the Board, Jones and Laughlin Steel Corp.

Thursday, January 15

9:30 a.m. Grand Ballroom

Chairman—W. G. AINSLEY, Sinclair Research Laboratories, Inc.
Secretary—H. D. YOUNG, Sinclair Research Laboratories, Inc.

General Motors "Model 51" Diesel Engine
JOHN DICKSON and R. D. WELLINGTON, Detroit Diesel Engine Division, GMC

All about the new General Motors 3000 rpm loop-scavenged diesel engine of 4.1 bore and stroke. Problems encountered in its development are as interesting as results of laboratory and field tests.

Simplifying Fuel Injection
VERNON ROOSA, Hartford Machine Screw Co., Inc.

The Roosa-Master fuel injection pump invites attention for what it doesn't have or need. No lubrication, poppet valves, complicated springs, gears, ball bearings, calibration, or operating adjustments!

(Sponsored by Diesel Engine Activity)

9:30 a.m. Crystal Room

Chairman—W. C. LAWRENCE, American Airlines, Inc.

Protective Design in Forward and Rearward Facing Seats in Transport Aircraft
HUGH DeHAVEN, Crash Injury Research, Cornell University Medical College

Requirements for aircraft seats exceed space and comfort needs, now contemplate passen-

ger protection in ditchings, belly landings, and more serious mishaps. Military aircraft use rearward-facing seats, but new designs make forward-facing seats safer too.

Economic Aspects of Incentive System for Maintenance and Overhaul
HUGH GORDON, British European Airways

Incentive systems, based upon piece work instead of straight time, have advantages and disadvantages, yet may make for economy. This paper reviews the experience of the pioneer operator in the field.

(Sponsored by Air Transport Activity)

2:00 p.m. Grand Ballroom
Chairman—J. W. PENNINGTON, Koppers Co.
Secretary—L. D. THOMPSON, Fairbanks, Morse and Co.
Business Session of Diesel Engine Activity

Engine Cylinder-Pressure Measurements
J. D. McCULLOUGH, Ethyl Corp.

Reliable fuel and engine research requires proper use of cylinder pressure instrumentation lest fallacious data lead to wrong conclusions. Tells what to avoid.

Measuring Rate of Fuel Injection in an Operating Engine
W. A. TURUNEN, H. R. MITCHELL, and R. J. WEHRMAN, Research Laboratories Division, GMC

Strain gages, which materialize in strange places doing stranger jobs, now have been put to work as pressure-measuring devices attached to fuel injectors. They reveal injector performance while engines are operating, and other new data.

(Sponsored by Diesel Engine Activity)

2:00 p.m. Crystal Room
Chairman—A. W. DALLAS, Air Transport Association of America
Secretary—WHITNEY COLLINS, Continental Aviation and Engineering Corp.
Business Session of Air Transport Activity

Panel Discussion on Turbine Powered Aircraft

Differences in the Design and Operation of Military and Commercial Transport Turbine Engines
R. T. HOLLAND, General Electric Co.

Maintenance Considerations in Design
MARSHALL GALLIERS, Wright Aeronautical Division, Curtiss-Wright Corp.

Cost Savings by Component Replacement in Line Maintenance
C. E. DIXON, Allison Division, General Motors Corp.

Some Considerations Regarding Fuels for Turbine Powered Transports
P. D. DORAN, Pratt and Whitney Aircraft Division, United Aircraft Corp.

Effect on Direct Operating Cost of Frontal Area, Specific Fuel Consumption, and Engine Weights
J. E. STEINER, Boeing Airplane Co.

Of vital importance to the air transportation industry are economic factors related to the design, maintenance, and commercial operation of turbine-powered aircraft. The panel compares essential features of military and civilian operations on the basis of dollars and sense.

(Sponsored by Air Transport Activity)

8:00 p.m. Grand Ballroom
Chairman—MALCOLM FERGUSON, President, Bendix Aviation Corp.

An Airplane Designer's View of Combat Airplane Reliability
I. H. DRIGGS and J. E. FORRY, Bureau of Aeronautics

Objective of combat aircraft is enemy damage. Efficiency is gained by developing planes inflicting maximum damage with minimum expenditures of time, money, and manpower. Reliability relates input to output, minimizes maintenance.

Prepared discussion by:
R. L. HALL, Grumman Aircraft Engineering Corp.
KENDALL PERKINS, McDonnell Aircraft Corp.

The Systems Approach to Air Weapons Development
MAJOR GENERAL D. L. PUTT, USAF, Vice Commander, Air Research and Development Command

Integrated weapons systems, which include human operators, afford optimum compromises between performance, striking power, and passive defense. Also, significant changes in Air Force organization, management, and relationships with industry. Systems design has a new philosophy and perspective.

(Sponsored by Aircraft Activity)

Friday, January 16

9:30 a.m. Grand Ballroom
Chairman—J. G. MOXEY, JR., Sun Oil Co.
Secretary—F. C. BURK, Atlantic Refining Co.

The Economy Run—Par for Gasoline Mileage
W. S. MOUNT, Socony-Vacuum Oil Co., Inc.

Phenomenal gasoline mileages recorded in three annual economy runs between Los Angeles, Grand Canyon, and Sun Valley have raised questions as to driving techniques and engineering design for economy. This paper tells how the high mileages are obtained.

Service Experience with TCP Fuel Additive
C. R. JOHNSON and D. N. HARRIS, Shell Oil Co.

Comprehensive review of the results of exhaustive military and commercial airline testing of a new aviation fuel additive which reduces spark plug fouling, even during manual leaning operations.

To be presented by title:
The Effect of Combustion Time on Knock in a Spark-Ignition Engine
D. R. DIGGS, E. I. du Pont de Nemours and Co., Inc.

Burning fuel-air mixtures before knock-producing materials form solves a chronic, critical problem. New tests, using single-cylinder engines with 17 spark plugs, show how far octane requirements can be reduced—and what else happens!

(Sponsored by Fuels and Lubricants Activity)

9:30 a.m. Crystal Room
Chairman—J. B. JOHNSON, Wright Air Development Center
Secretary—J. R. LONG, National Research Council
Business Session of Aircraft Activity

Symposium on Titanium

The Bases for Tonnage Titanium Production
C. I. BRADFORD, Rem-Cru Titanium, Inc.

Titanium Alloy Development
M. HANSEN and H. D. KESSLER, Armour Research Foundation, Illinois Institute of Technology

Utilization of Titanium and Other Alloys in Corrosive Environments
W. L. WILLIAMS, U. S. Naval Engineering Experiment Station, Annapolis

Titanium Alloys for Aircraft Engine Forgings
L. R. FRAZIER, Thomson Laboratory, General Electric Co.

Titanium in Airframes
F. R. KOSTOCH, North American Aviation, Inc.

Engineers are beginning to believe titanium is called the "wonder metal" because it makes them wonder whether it will create more problems than it solves. This symposium reviews and consolidates technical wonderment—up to now!

(Sponsored by Aircraft Activity)

2:00 p.m. Grand Ballroom
Chairman—F. A. SUESS, Continental Oil Co.
Secretary—J. E. KLINE, Standard Oil Co. (Indiana)
Business Session of Fuels and Lubricants Activity
Presentation of HORNING MEMORIAL AWARD to L. F. DUMONT by J. R. SABINA, Chairman, Horning Memorial Board of Award

A Method for Identifying Preignition
R. F. WINCH and F. M. MAYES, Sun Oil Co.

Increases in compression ratios and power output necessitate identification of preignition. New, simple method, used in the laboratory or on the road, puts the finger even on mild preignition, distinguishes between preignition and detonation.

A Low Temperature Sludging Test
J. G. McNAB, M. E. CONN, D. S. McARTHUR, and K. L. STEHLE, Esso Laboratories, Standard Oil Development Co.

New test techniques correctly predict the field performance of motor oils in resisting sludge formation during low-temperature, stop-and-go driving. Procedure is described in detail.

(Sponsored by Fuels and Lubricants Activity)

About SAE Members

DONALD H. SPICER has been elected vice-president in charge of manufacturers' sales of the American Bosch Corp., Springfield, Mass. Spicer had been president of World Bestos Corp., a division of Firestone Tire and Rubber Co., since 1941. He recently served two terms as president of the Brake Lining Manufacturers Association, and has been a director of the Friction Materials Standards Institute.

LT. GEN. JAMES H. DOOLITTLE has been chosen to receive the Wright Brothers Memorial Trophy, the National Aeronautic Association announced recently. General Doolittle will receive the trophy for his "significant public service of enduring value to aviation" at a banquet at the Washington, D. C., Aero Club on Dec. 17, the 49th anniversary of the Wright brothers first flight at Kitty Hawk. Doolittle is also chairman of the recently-organized National Committee to Observe the 50th Anniversary of Powered Flight, which will open a year-long celebration of the Wright brothers achievement on Dec. 17.

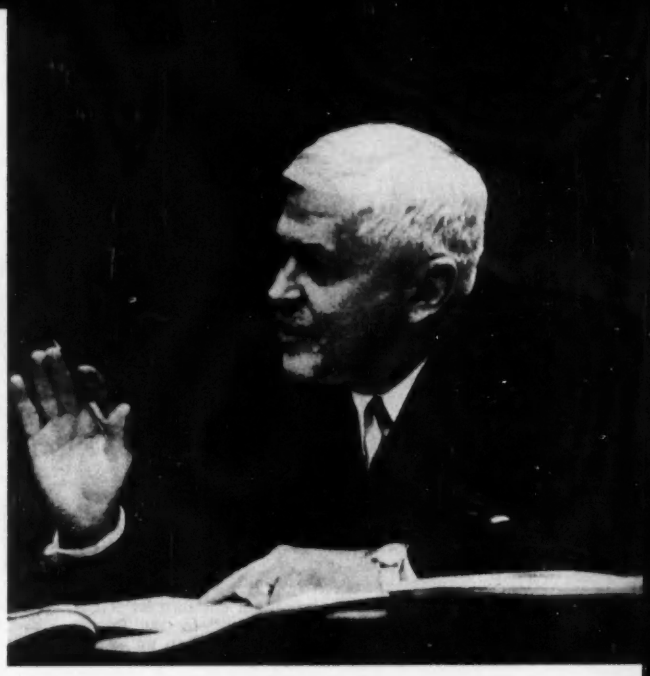
RICHARD T. KARR, who was formerly a sales engineer in the Detroit office of Purolator Products, Inc., has been appointed assistant to **CARLOS D. KELLY**, vice-president in charge of sales. Karr will make his headquarters at the company's main offices in Rahway, N. J. He has been with Purolator since 1937, except for wartime service in the Air Force.

THOMAS L. FAWICK was named chairman of the board and **RICHARD S. HUXTABLE** was named president of the newly formed Federal Fawick Corp. The new company was formed in a merger of Fawick Airflex, Inc., of Cleveland, and Federal Motor Truck Co., of Detroit. It will operate the Fawick Airflex Division in Cleveland and the Federal Truck and Brake Divisions in Detroit. Fawick was president of Fawick Airflex, Inc. Huxtable was executive vice president and general manager of Fawick Airflex. Huxtable will continue as general manager of the Cleveland division in addition to being president of the newly formed parent company.

RAYMOND C. McCULLOUGH has been named manager of extrusion sales for Bohn Aluminum and Brass Corp., Detroit. McCullough was formerly Chicago district manager for Bohn.

H. L. RITTENHOUSE has been appointed to the newly-created position of manager, product development and engineering, for Euclid Road Machinery Co., Cleveland, Ohio. Rittenhouse was previously Euclid's chief engineer. **CARL F. KOENIG**, former assistant chief engineer, has been promoted to chief development engineer and **LOUIS F. HELD**, former product engineer, to chief product engineer. **ELMER A. KEMP** becomes staff engineer in charge of components and cost control, and **RAYMOND P. VINCENT**, who until this year was chief draftsman at Euclid (Great Britain), Ltd., becomes engineering office supervisor.

Wilson Named Secretary of Defense



CHARLES E. WILSON, president of General Motors, has been named Secretary of Defense in the Eisenhower cabinet. When he assumes his new office, he will sever all business connections and devote his entire time to the job.

Commenting on the appointment, **ALFRED P. SLOAN**, General Motors' board chairman, voiced a conviction which is shared widely by Wilson's fellow members of SAE. Sloan said: "As a technician and a coordinator he can bring to the problems of our national defense an experience in large affairs and a demonstrated ability equalled by few."

Wilson, who is scheduled to introduce Admiral Ben Moreell, the chief speaker, at SAE's 1953 Annual Meeting Dinner in Detroit on Jan. 14, is the second member of SAE to have achieved cabinet rank.

BRENT C. JACOB, JR., has been appointed supervisor of quality inspection for Chrysler Corp. on the staff of the operating manager. Jacob received his master's degree from Chrysler Institute of Engineering in 1940 and joined the corporation at the Highland Park plant. He served three years in the U. S. Navy and was a lieutenant commander in charge of auxiliary powerplant development at the Naval Air Station in Philadelphia when he was discharged and rejoined Chrysler Corp. in 1945.

FRANK J. DRUAR, who since 1930 had been with Bower Roller Bearing Co., Detroit, as sales engineer and assistant sales manager, retired from Bower last summer and now lives in Mt. Dora, Fla. An SAE member since 1920, Druar has now also joined the orange and the grape growers' associations . . . and reports that the fishing in Lake Dora is fine.

CHARLES A. CHAYNE, General Motors vice-president in charge of engineering, delivered the James Clayton lecture before the Automobile Division of the Institution of Mechanical Engineers Nov. 4 in London. Speaking on "Automatic Transmissions in America," Chayne said: "Automatic drive is no longer considered a novelty or luxury. It has proved itself as being the correct engineering approach for taking engine power and putting it to work properly." Chayne repeated his talk Nov. 6 in Glasgow before the Scottish Branch of the Institution.

A. S. RANDAK has been released from active duty with the Air Force and has re-joined Sinclair Refining Co., New York City, as manager of technical service. He will be responsible for directing all technical and engineering services relating to the sale of products, and will direct and coordinate all technical matters in product development with the refining and research divisions. Randak has been serving the Air Force as a colonel and special assistant to the vice-commander at Headquarters, Air Research and Development Command, Washington, D. C., and will continue to serve as a consultant to ARDC.

A. O. WILLIAMS has been appointed director of engineering of the industrial truck division of Clark Equipment Co., Battle Creek, Mich. Williams has been engaged in new product research for the industrial truck division for the past year, and prior to that was chief engineer and later general manager of Clark's railway division. He has been with Clark since 1917.

PIERRE J. MAUCK, executive assistant for engineering at GMC's Fisher Body Division, retired recently after 30 years with the division. Mauck was first employed as assistant production manager at Fisher Body's Cleveland plant in 1922, and went to Detroit in 1929 as director of production engineering. He was named executive assistant for engineering in 1949.

HELENE A. ROTHER, consultant designer for Nash-Kelvinator Corp., has been named a "woman of achievement" by the Detroit Historical Society. Her photographic portrait will be included in an exhibit at the Detroit Historical Museum in January and February. Mrs. Rother, who was educated in France and Germany, came to the United States in 1941 and joined the styling section of General Motors Corp. She has spoken on automotive styling before Detroit Section.

I. M. HAMER has been elected technical director of Dowty Equipment of Canada, Ltd., Ajax, Ont. Hamer has been chief engineer of the company for the past 10 years. He joined the parent company in England in 1940.

EDWIN D. SCOTT has joined the American Forging and Socket Co., Pontiac, Mich., to head its research and development staff. Scott was with Ford Motor Co., for many years, and was one of the first Ford technical advisers assigned to the B-24 project at Willow Run. He has served on Body Activity committees of SAE.

EMERY B. KEREKES has been named assistant to the vice-president of Hydropress, Inc., and its subsidiary, the Loewy Construction Co., Inc., New York City. Kerekes was previously manager of gas turbine production for the Elliott Co., Jeannette, Pa., and has served on the governing board of Pittsburgh Section.

DAVID A. WALLACE, president of Chrysler Division of Chrysler Corp., addressed the annual fall conference of the Society for Advancement of Management on Oct. 31 in New York City. Speaking on "Automation," Wallace covered the application of automatic processes to quantity-production manufacturing as an aid to both quality and speed.

FRANK A. TIEDGE has been named regional truck manager for Dodge Division of Chrysler Corp. in the Philadelphia region. Tiedge joined Dodge in 1950 as district manager in the Cincinnati region. During World War II he served for more than three years in the Air Force.

JEROME HUNSAKER'S "Aeronautics at the Mid-Century," based on the Terry lectures he delivered at Yale in 1951, has just been published by the Yale University Press at $3. The first chapter discusses the state of technology from which the Wright Brothers' invention arose and outlines the subsequent development of that invention. The next describes the present state of the art, principally as it applies to air transportation. The last chapter has to do with the impact of both civil and military aeronautics on our society. The good or evil of aeronautic advancements depends on the adjustments society makes to them, Hunsaker emphasizes.

LT. COL. JOHN H. CUNNINGHAM is now at the Transportation Corps' transportation research and development station at Fort Eustis, Va., as chairman of the commercial trucking study group. Colonel Cunningham was previously professor of military science and tactics for the ROTC at the University of Oregon. While at the University, Cunningham took a master's degree in business administration.

WALTER E. JOMINY of Chrysler Corp. and past president of the American Society of Metals, has been named a trustee of the Society's new Foundation for Education and Research. Assets of the Foundation will provide a yearly income of about $30,000 to be used for the advancement and dissemination of scientific knowledge, particularly with respect to metals technology, either through education and research carried on by the Foundation or through support of educational and research activities in established organizations.

HENRY A. FREDRICKSON has joined North American Aviation, Inc., Downey, Calif., as a research engineer. He was previously a group leader at the University of Michigan's Willow Run research center.

R. E. MOONEY has been named sales manager for the Ohio and western Pennsylvania districts for the Cleveland Graphite Bronze Co., Cleveland. He was previously sales manager for the Michigan district.

GORDON H. MILLAR has joined the research laboratories of Ethyl Corp., Detroit, as research engineer. He was previously a research assistant at the University of Wisconsin, and recently received his doctorate from the University after research in combustion problems carried out under **DR. PHILLIP S. MYERS** and **DR. OTTO A. UYEHARA.**

RAY M. CAMPFIELD is now an industrial engineer at the U. S. Naval Ordnance Laboratory at Silver Spring, Md. He was previously with Brockway Glass Co., Brockway, Pa., as a mechanical engineer.

DONALD DOUGLAS, president, Douglas Aircraft Co., and **JOHN B. RAUEN,** president of U. S. Spring and Bumper Co., are, members of the recently organized Business Executives' Advisory Council for Southern California. First analytical study by the group will be on "Some Aspects of Past-mobilization in Southern California. What will happen? When?" The study will be a joint project of Occidental College and Pomona College with the sponsorship of the Committee for Economic Development.

EDWARD P. BOLEN has been elected a vice-president of National Automotive Fibres, Inc., Detroit. Bolen has been in charge of trim engineering for the company's automotive divisions since 1935. He joined the company in 1929 as superintendent of the Detroit plant.

ROBERT L. GATES is now plant metallurgist for Wooster Division of Borg-Warner Corp., Wooster, Ohio. Gates was formerly with Thompson Products, Inc., Cleveland, Ohio, as research engineer.

WALTER R. VIGNINI has been named supervisor of production engineering at the Cold Spring, N. Y., plant of Sonotone Corp. He was previously in charge of production engineering at Sonotone's plant in Port Chester, N. Y.

CARL M. BLISS is now contact engineer at GMC's Chevrolet experimental laboratory, Detroit. He was formerly assistant staff engineer at Cadillac Motor Division's Cleveland Tank Plant.

E. T. HORSEY is now president of Randolph Mfg. Co., Cleveland. Horsey was formerly a sales engineer for Bradford Products Co. in Cleveland.

E. P. BLANCHARD has joined Morey & Co., prominent machinery dealers, in New York City in an advisory and consulting capacity in coordination of the several branches of the company's business, following the completion of his assignment as consultant to the Machine Tool Division of the National Production Administration in Washington, D. C. Blanchard was for many years director of sales of the Bullard Co. of Bridgeport, Conn., from which he retired in 1950.

JOHN R. DZIEL has been promoted to assistant to the chief engineer of Fairchild Engine Division of Fairchild Engine and Airplane Corp., Farmingdale, N. Y. Dziel was previously chief draftsman. He is a member of SAE's S_1 committee on the aeronautical drafting manual and chairman of S_1's checking committee. He is also S_1's participant in SAE's joint aeronautical-automotive study of British standards.

W. A. McCUTCHEON has been released from active duty with the Army General Staff and is now a budget examiner for the military division of the Bureau of the Budget in Washington, D. C. McCutcheon has been on leave from the Bureau since March, 1951, serving first as chief of the program analysis and inspection section of the supply division's maintenance branch, and later with the office of the Chief of Transportation and the logistics branch. He is credited with having saved the government millions of dollars in the purchase of military motor vehicles.

RALPH S. PARKS has joined GMC's Oldsmobile Division, Lansing, Mich., as layout man in the engine design section. He was previously layout man in the engine section of Reo Motors, Inc. Parks was 1951 winner of Detroit Section's Henry Ford Memorial Award.

D. Y. MILNE has been named director of the muffler laboratory, in charge of research and development, for Maremont Automotive Products, Inc., Harvey, Ill. Milne, who has been with Maremont for four years, was previously research engineer in the muffler laboratory.

SAE Members Are Saying . . .

"The largest commercial motor vehicle fleet in the world operates at its peak efficiency when it is standing still. . . . Such a paradoxical situation stems from the more than 60,000 vehicles which are operated each day by the Bell Telephone Companies—not trying to pile up mileage records, but merely providing storerooms, labor-aiding power machinery, and transportation for the men who construct, install, and maintain America's life lines of communication." . . . **F. K. Glynn,** automotive engineer, American Telephone and Telegraph Co., in an article in "Business on Wheels."

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"Our economic and political order has survived war, the threat of war, and the competition of totalitarian, socialistic economies. Invariably it has performed best when allowed to operate with a minimum of restrictions. Ill-advised and unnecessary tampering can in time dry up its basic productive force, which is the incentive of profits." . . . **L. L. Colbert,** Chrysler Corp., in an address at the University of Texas, Oct. 3, 1952.

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"We should do perhaps a little more than we think we can do. That's the way to get things done." . . . **K. T. Keller,** board chairman of Chrysler Corp., in telling how he once pledged over $9000 toward granite for a new church, and then had to rush to get a loan from the bankers to cover the pledge, since he had no such sum at hand. Keller told this anecdote at the dedication of the John F. and Horace E. Dodge Hall of Industry, at the Detroit Historical Museum.

• • •

"It is this strange, neurosis-like behaviourism — something like schizophrenia, I suppose—which transforms many a kind, genteel, God-fearing person into something of a hind when he gets behind the steering wheel." . . . **R. S. Wilson,** vice-president of the Goodyear Tire & Rubber Co., in addressing a meeting sponsored by the Philadelphia Chamber of Commerce and the National Council of Private Motor Truck Owners, Sept. 25.

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"The ratio of national income to farm income has been consistently 7 to 1, year in and year out. When agricultural income was high, national income was high . . . when they dropped, the ratio was still 7 to 1." . . . **Raymond C. Firestone,** vice-president of the Firestone Tire & Rubber Co., in a radio address on the General Electric Farm Forum over station WGY, Schenectady.

JOHN H. SEATON has been appointed superintendent of aircraft wheel and brake manufacturing for the B. F. Goodrich Co., Akron, Ohio. He will make his headquarters at the company's airplane wheel and brake plant in Troy, Ohio. Since 1946, Seaton has been general manager of the aeronautical manufacturing division. He joined Goodrich in 1927.

ALEXANDER HOSSACK has joined the American Locomotive Co., Schenectady, N. Y., as a project engineer. Hossack was formerly project engineer at the Detroit Arsenal, Centerline, Mich.

S. S. PIERCE has been transferred to Tinker Air Force Base, Oklahoma City, Okla., as assistant chief of the industrial engineering branch of the Maintenance Directorate. He was previously stationed at Wright-Patterson Air Force Base, Dayton, Ohio.

JEAN SCHNEEBERGER is now a design engineer for Schweitzer and Hussman, State College, Pa. Schneeberger was previously a draftsman for American Locomotive Co., Schenectady, N. Y.

FRED A. IRWIN is now superintendent of maintenance of Hancock Trucking, Inc., Evansville, Ind. He was formerly with Commercial Equipment Corp., Columbus, Ohio.

Z. N. BAKER has joined the White Motor Co. in Houston, Texas, as shop foreman. Baker was formerly shop foreman for Hunsaker Trucking Contractor, Inc., Houston.

JESSE J. SHORE is now with Master Craftsman Specialties, Irving, Texas, as chief product engineer. Shore was previously a teacher of automotive mechanics in Fort Worth, Texas.

M. G. BALES has been named electrical engineer on special assignment for Delco-Remy Division of General Motors, Anderson, Ind. Bales was formerly section engineer for the division.

JAMES B. LAWSON has been promoted to plant operator for the Tide Water Associated Oil Co. in Revere, Mass. He was formerly an engineer for the company.

LADISLAW G. SROGI has rejoined Ford Motor Co., Dearborn, Mich., as design engineer in the gas turbine group. Srogi was previously a senior engineer for Lycoming-Spencer Division of Avco Mfg. Corp. in Williamsport, Pa.

E. S. PARKS, who was formerly manager of the Genuine Parts Co., is now a partner in Aiken Auto Parts, Aiken, S. C.

CHRISTIAN L. JENSEN has joined Safety Motors, Inc., Chicago, Ill., as service manager. Jensen previously was service manager for Chicago Auto Sales.

EDWARD F. COLE, JR., who was formerly with Pratt and Whitney Aircraft, East Hartford, Conn., has joined Chrysler Corp. in Detroit as a laboratory engineer.

JACK M. CRAIG has been named merchandise sales manager for Pacific Airmotive Corp., Burbank, Calif. He was formerly secretary, treasurer and sales manager of Pacific Equipment Co., Los Angeles.

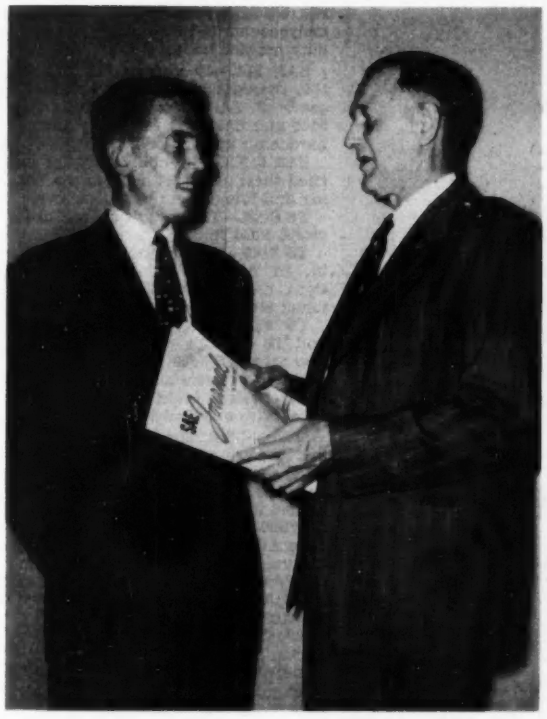
VERNON F. FISHTAHLER is now at the central office of GMC's Chevrolet Motor Division, Detroit, as project engineer on brakes, rear axles and brake hook-ups for passenger cars. He was formerly at the Cleveland Tank Plant of Cadillac Motor Division as assistant staff engineer on suspension and tracks.

LYNN G. BARNES is now second vice-president and general manager of the Omaha and Council Bluffs Street Railway Co., Omaha, Neb. Barnes was previously vice-president and manager of engineering of Twin City Rapid Transit Co. in Minneapolis.

HERMAN J. STAGGENBURG has been named assistant manager of Delco battery operations for Delco-Remy Division of General Motors Corp., Muncie, Ind. Staggenburg was formerly plant engineer at Delco-Remy's plant in Anderson, Ind.

REX F. JEIDE has been promoted to assistant industrial sales manager for the Minneapolis-Moline Co., Minneapolis. Jeide was previously technical sales engineer for Minneapolis-Moline's industrial sales department.

SAE Fathers and Sons



Father and son team at the recent SAE National Transportation Meeting in Pittsburgh was **L. A. CARLSON** (right), general superintendent of distribution for Gulf Oil Co., and **L. A. CARLSON, JR.**, project engineer for the industrial parts division of the aircraft section of Westinghouse Air Brake Co.

Snapped together at the SAE National Aeronautic Meeting in Los Angeles are **W. C. HEATH**, chief engineer of Solar Aircraft Co., and his son, **W. C. HEATH, JR.**, who is weight analyst at the El Segundo Division of Douglas Aircraft Co.

TECHNICAL COMMITTEE *Progress*

ISTC Panel D Members Swap Data on Application of Alternate Steels

THE steel situation has clarified itself to the point where users know what alloys are really scarce and what alternate steels are satisfactory for particular applications. This was evident at the last meeting of Panel D—Tractor & Earthmoving Equipment of the SAE Iron and Steel Technical Committee.

A CMP ticket is still only a hunting license. But chromium and manganese appear to be in nearly adequate supply as long as we stay out of war. And an easing in molybdenum steel allotments is expected before the end of 1952.

Nickel is, of course, still scarce, Panel D members continued. It's scarce now when we are building jet aircraft at the rate of 7500 per year; it will probably be scarcer in 1953 when the annual rate goes up to 10,800 jet aircraft, H. B. Knowlton of International Harvester warned.

SAE 25XX 5%-nickel steels and SAE 31XX nickel-chromium steels are no longer being produced. Panel D was told. The 3.5%-nickel SAE 48XX steels are being allowed only for rock bit cutters and a few hardship cases where shops would have to shut down without it. The hardship cases must prove they are trying to make a substitution.

In another year or two, we may not even have the TS 86XX steels, Porter Wray of U. S. Steel told Panel D. (The TS 86XX steels are tentative standard 0.45 and 0.55% nickel steels whose compositions have been published by the American Iron and Steel Institute.)

Here is a run-down on alternate steels as Panel D members discussed them:

SAE 1046—International Harvester is making tractor spur gears out of this plain carbon steel and induction hardening them.

SAE 13XX—These grades are growing in popularity. GMC divisions are finding use for 1345.

AISI 4118—This steel—which is one AISI lists as appearing to be among those "least affected by governmental restrictions in the use of nickel and molybdenum"—IH is using for heavy-duty crawler tractor gears.

SAE 5140—Deere and Co. is using this successfully for one transmission gear. J. I. Case is using both SAE 5140 and SAE 5145 for some through-hardening applications.

SAE 61XX—Caterpillar Tractor has tried these steels for medium hardening and found them unsatisfactory.

TS 812X—These steels are useful for gears, Ford finds.

TS 8140—For certain shafts up to 6 in. in diameter, Link-Belt Speeder Corp. uses this 0.3-nickel, 0.4% chromium steel.

TS 86XX—Ford is using TS 8620 and TS 8622 for gears. J. I. Case is also using TS 8620 for carburizing applications. Deere and Co. is using TS 86XX steels to avoid distortion experienced with other alternate steels.

50B20—This chromium-boron steel has been used successfully in small bevel gears by International Harvester. In other 50BXX steels, the gears tended to distort.

80B20—Ford is using this for differential spider gears. Oliver Corp. has used some 80B20 along with 80B17 and TS 94B17, but they intend to discontinue the boron steels because of growth troubles.

80BXX—These steels find little favor among Panel D participants.

81BXX—Deere and Co. tried 81BXX steels for gears, but distortion was so severe that they went back to SAE 86XX steels.

Panel D members listen to a word from Chairman Muir Frey during the meeting they held in conjunction with the SAE National Tractor Meeting in Milwaukee

Gasket Group Seeks Clearer Definitions

MORE descriptive definitions of the various fiber and filler classifications for gaskets are being sought by a study group of Section X—Gaskets of the SAE-ASTM Technical Committee on Automotive Rubber. The study group does not intend to alter numerical classifications.

Need for better definitions became apparent when the new beater-mixed fiber compositions were offered recently for inclusion in ASTM D-1170. (The SAE Recommended Practice on Nonmetallic Gaskets for General Automotive and Aeronautical Purposes (SAE 90R) conforms to D-1170-51T, which is the current version of this American Society for Testing Materials specification.)

Section X has set up a round-robin test program to find out if results from the mullen test correlate with tensile test results. Stress relaxation is also under study within Section X.

J. M. Clark of Packard is chairman of Section X.

First Five AMS's on Titanium Completed and Issued in November

FIVE Aeronautical Material Specifications on titanium—believed to be the first specifications on titanium issued by any standardizing organization—were issued last month. They were developed by the AMS Division's Carbon and Low-Alloy Steels and Titanium Commodity Committee under the leadership of Bishop Clements of Wright Aeronautical. The five specifications are:

- AMS 4900 — Titanium Sheet and Strip, Annealed—55,000 psi Yield
- AMS 4901 — Titanium Sheet and Strip, Annealed—70,000 psi Yield
- AMS 4908 — Titanium Alloy Sheet, 8 Mn, Annealed—110,000 Yield
- AMS 4921 — Titanium, 99 Ti, Annealed—70,000 psi Yield
- AMS 4925 — Titanium Alloy 4 Al-4 Mn, Annealed—130,000 psi Yield

Bishop Clements

Reason that yield strength is given in the titles of these specifications instead of tensile strength is that titanium's yield strength—which is usually the important strength value for design considerations—is a high proportion of tensile strength, Clements explains. Each of the five specifications calls out a minimum yield strength only 10,000 psi lower than the corresponding tensile strength. This gives a yield strength/tensile strength ratio considerably higher than most steels and other common structural metals.

Tensile requirements apply "when the rate of strain is maintained at approximately 0.005 in. per in. per minute to the yield strength," each of the five AMS's says. That is because some investigators believe that, for titanium, the rate of strain influences strength results. Besides physical properties, the AMS's cover composition, condition, bending requirement, quality, tolerances, accompanying reports, and identification markings.

AMS 4900 and AMS 4901 are for sheet and strip primarily for parts requiring strength up to 400 F and oxidation resistance up to 600 F. AMS 4908, which calls for 7-9% manganese, is for titanium alloy sheet for parts requiring strength up to 600 F and oxidation resistance up to 800 F.

AMS 4921, a 99% titanium composition for bars, forgings, and forging stock, is primarily for parts requiring strength up to 400 F and oxidation resistance up to 600 F. AMS 4925, a 4% aluminum, 4% manganese alloy—also for bars, forgings, and forging stock—is for parts requiring strength up to 750 F and oxidation resistance up to 800 F. All five of the specifications limit carbon to 0.20%.

The elevated-temperature qualifications written into the specifications will give designers a basis for choosing between titanium and aluminum or steel for structures subject to heating from aerodynamic friction or from engines. On a strength-weight basis, titanium has advantages over aluminum at about 400 F and over and, under about 1000 F, over stainless steel. Above about 1000 F titanium picks up carbon, oxygen, and nitrogen—all of which tend to embrittle the metal—but it is still useful as a flame barrier. The oxide film that titanium forms even at room temperatures makes it resistant to many of the agents that corrode steel. These are the reasons for using materials so hard to produce that they cost $5-$15 per lb. Airframe manufacturers are specifying and paying the price for titanium sheet for fire shields. Engine manufacturers are considering using titanium for compressor housings and possibly compressor blades. And more use will be made of titanium as more titanium becomes available, Clements' committee expects.

Right now titanium is scarce because it is difficult to process. In the molten stage, titanium combines with carbon from the furnace lining and oxygen from the air. Both contaminants are detrimental to titanium's physical properties. There is hope that a way of circumventing these difficulties will be found soon. Meantime, producers are not eager to invest heavily in equipment for presently known refining processes.

The Defense Production Administration has, however, laid plans for expanding titanium production to the point where annual production will reach 22,000 short tons in 1955. As production goes up, prices can be expected to come down, and titanium will be used in a greater variety of aeronautical applications. Eventually the AMS Division will probably be developing more specifications in the AMS 49XX block set aside for titanium.

The Division has been following titanium developments for several years, awaiting the time when enough experience would have been accumulated on which to base specifications. Last summer—in view of the data available, aircraft industry and government interest, and a suggestion from James D. Redding of the Committee on Aeronautics of the Department of Defense's Research and Development Board—the time seemed ripe to begin work on titanium specifications.

The resulting five titanium AMS's are available at 11¢ each from SAE headquarters, 29 West 39th St., New York 18, N. Y.

Broad Changes Made in Tire Simplification Lists

TIRE simplification lists in the SAE Recommended Practice entitled, "Haulage and Grader Tires and Off-Highway Rim Classification," won't look or be the same in the 1953 SAE Handbook.

Tables 1 and 2, and most of the recommendations in them covering tire section and rim diameters and ply combinations for haulage and grader tires, will remain. But Table 3, with its off-highway rim classifications for haulage tires, will be gone. It has been

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eliminated to avoid conflict with Tire and Rim Association Tables.

What's more, Table 1 will no longer have the 16.00-20 size. But it will include a 16.00-21 size in 16-, 20-, and 24-ply constructions, and an 18.00-33 size with 32 plies.

Table 2, on the other hand, has dropped sizes 7.00-24 and 8.25-20 because they no longer are used as original equipment. And the 14-ply rating for the 14.00-24 size has been changed to 12-ply to conform to current modifications.

Other changes made by the SAE Construction and Industrial Machinery Technical Committee—and indorsed by the SAE Technical Board—are the footnotes under both of these tables. They have been modified editorially.

CRC Probes Deposits At Dearborn Meeting

Feature attraction at the dinner session at CRC's two-day meeting on combustion chamber deposits was a talk on factors affecting combustion by Prof. R. W. G. Norrish (second from left), of Cambridge University, England. Shown with him are (left to right): M. K. McLeod, manager of CRC; T. B. Rendel, chairman of the Coordinating Fuels and Equipment Research Committee; and E. N. Cole, chief engineer of Chevrolet, who was toastmaster

ONE of the more valuable and useful ways of insuring true cooperation between the petroleum and automotive industries available to the Coordinating Fuels and Equipment Research Committee is the organization of symposia on various phases of fuel-lubricant-engine relationship. Such symposia are extremely valuable when it comes to exploring fields of probable research work where the distinction between the competitive problems and those problems where cooperative research is possible is not too well defined. One of such fields, at the moment, is the question of combustion chamber deposits and their effect on the operation of the engine, particularly in regard to the phenomena of knocking and pre-ignition.

Last September, the CFR Committee, in cooperation with the Cooperative Lubricants Research Committee, organized a symposium of 18 different papers on this subject. The actual details of the organization of the symposium were handled by the Equipment Survey Group of the Motor Fuels Division of the CFR Committee. With the objective of holding the group together not only in official session, but also in informal discussion sessions throughout the evening, the CFR Committee also organized a dinner meeting, which was followed by an extremely interesting lecture by Professor R. W. G. Norrish, professor of physical chemistry at Cambridge University, and one of the foremost authorities on chemical kinetics. Professor Norrish's talk was on the more fundamental aspects of combustion and on his investigations into combustion reactions by photochemical analysis.

The symposium was conducted under the chairmanship of Dr. W. J. Sweeney of Esso Development, and was ably summarized at the end of the two-day session by J. M. Campbell of General Motors Research. Papers were divided into two groups—one dealing with reports on the effects of deposits on such items as power output, valve life, octane requirement increase and pre-ignition—and the other group dealing with reports on test techniques of methods of evaluation, both in the field and in the laboratory. A very lively and interesting discussion took place on many of the papers.

Perhaps one of the most interesting points brought out by the discussions was the fact that, for motor fuels in the higher brackets, the petroleum industry would be faced with extremely heavy capital expenditures in the future to produce octane number increases of the order of three to four; but combustion chamber deposits and other effects in the motor engine could often result in octane number requirement increases of the order of seven to ten.

Therefore, whatever could be done to alleviate the effect of combustion chamber deposits on octane number requirement increase, would result in a far more profitable field of investigation than in raising the octane number of the basic fuels themselves.

The CFR Committee agreed to publish all reports as soon as possible for the benefit of those attending the meeting, and submit them for further study to appropriate groups. Such studies would have as their objective preparation of a cooperative program, if one seems to be desirable.

23 AMS Approved By Technical Board

- AMS 2675—Nickel Alloy Brazing
- AMS 3301B—Silicone Rubber, General Purpose (35-45)
- AMS 3302B—Silicone Rubber, General Purpose (45-55)
- AMS 3303C—Silicone Rubber, General Purpose (55-65)
- AMS 3304B — Silicone Rubber, Low Compression Set (65-75)
- AMS 3305C — Silicone Rubber, Low Compression Set (75-85)
- AMS 3315A—Silicone Rubber Sheet, Glass Fabric Reinforced
- AMS 3320A—Silicone Rubber Sheet, Glass Fabric Reinforced, Heat and Weather Resistant (60-80)
- AMS 4640C—Aluminum Bronze
- AMS 4750A—Solder, Tin-Lead
- AMS 4900—Titanium Sheet and Strip, Annealed—55,000 psi Yield
- AMS 4901—Titanium Sheet and Strip, Annealed—70,000 psi Yield
- AMS 4908 — Titanium Alloy Sheet, 8Mn, Annealed—110,000 Yield
- AMS 4921—Titanium, 99Ti, Annealed —70,000 psi Yield
- AMS 4925 — Titanium Alloy 4Al — 4Mn, Annealed—130,000 psi Yield
- AMS 5506 — Steel Sheet and Strip, Corrosion and Moderate Heat Resistant
- AMS 5523 — Steel Sheet and Strip, Corrosion and Heat Resistant
- AMS 5574 — Steel Tubing, Seamless, Corrosion and Heat Resistant
- AMS 5621—Steel, Corrosion and Moderate Heat Resistant
- AMS 5631—Steel, Corrosion Resistant
- AMS 5650—Steel, Corrosion and Heat Resistant
- AMS 7270A — Rings, Sealing, Synthetic Rubber, Fuel Resistant
- AMS 7274B — Rings, Sealing, Synthetic Rubber, Oil Resistant

ISTC Div. XXVI Exchanges Data on Shell Molding

FOUNDERS and designers are gaining experience with the relatively new shell molding process—and sharing it through Division XXVI—Shell Molding, of the SAE Iron and Steel Technical Committee.

Several vehicle manufacturers have installed shell molding machinery and are using it to great advantage. A few job foundries are also in large-scale production of shell-mold castings. Many more job foundries are interested in the process and will undoubtedly acquire automatic shell-making equipment when they can secure enough contracts for their shell-mold castings to justify the outlay.

It is the automatic shell-making equipment that makes the process attractive cost-wise. Essentially the equipment inverts a box enclosing the heated pattern and the dry sand-resin mixture so that the mixture falls on the pattern. Some of the mixture adheres to the pattern, forming the "shell" mold. The rest falls away when the box is revolved to its original position.

Some automobile producers are using their automatic shell-molding equipment to turn out molds for automatic transmission parts that were formerly die cast. Some producers are also casting camshafts, crankshafts, and valves in shell molds. Makers of agricultural implements are producing grey iron gears in shell molds. Aircraft engine manufacturers have experimented with making compressor and turbine blades and other small parts by the shell molding process.

V. A. Crosby (left) and Division XXVI Chairman C. O. Burgess at the Division's Sept. 17 meeting

In most cases where manufacturers have switched from green-sand molds to shell molds they have done it because the latter yield castings that require less machining, it was emphasized at Division XXVI's meeting. Much closer tolerances can be held with shell molds, and surface finish is better too. Closest tolerances are possible, of course, when parts are designed so that there is only one draw and therefore no parting line.

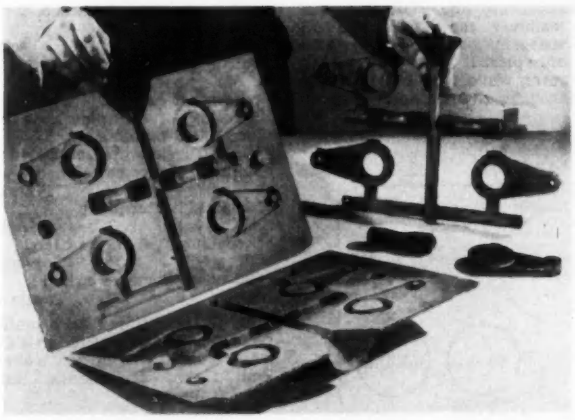
Users of shell molds find they scrap far fewer castings than they did with green-sand molds. Shell molds are porous enough to let escape from the molten metals the gases which would otherwise make the casting porous. Shell mold castings are cleaner too, partly because of the way cores are used.

Division XXVI members report that they don't have to scrap castings due to faulty shell molds, as happens with green-sand molds. If the sand-resin mixture for the shell isn't right, there's no shell.

The accuracy of the shell molding process makes it worthy of the best in pattern making, Division XXVI participants agreed. Only $\frac{1}{4}$ to $\frac{1}{2}$ deg draft angle is required to withdraw the pattern from the shell mold instead of the $1\frac{1}{2}$ deg or so needed with green sand.

Shells for use without back-up are usually 3/16 to $\frac{3}{8}$ in. thick. The thinner the mold, the faster the heat of the molten metal dissipates, and the stronger and harder the casting. Backing up the shell with sand or shot supports the casting. Shot conducts heat away faster and gives a hardness about 10 Bhn higher than sand back-up does, Division XXVI was told.

For a given number of molds, cost



Shown here are two halves of a shell mold and the casting produced from it. They illustrate the process with which ISTC Division XXVI is concerned. The mold halves are made in a machine which applies a sand-resin mixture to a hot pattern plate coated with a parting agent. A sand-resin crust or shell adheres to the pattern plate.

Pattern and shell go into an oven to harden the shell before it is stripped from the pattern. Cured mold halves are clamped together, placed in a flask, and surrounded by steel shot or other back-up material. Then the metal is poured into the shell mold. When the casting has cooled, the mold is knocked off and discarded.

of shell-mold material is generally higher than cost of green sand. One Division XXVI member pointed out that if you use 6% resin at 35¢ per lb and a special sand, the materials cost per ton of shell molds is about $50. A crankshaft cast with bakes and cores in stacks requires about one ton of shell molds—that is, about $50 worth of sand and resin—per ton of crankshafts. To cast the same number of crankshafts by old methods would take four tons of green sand—or about $20 worth.

Shell molding is usually economical only where these higher costs of raw materials and first cost and maintenance costs of shell-making equipment are outweighed by savings in machining and scrap, it was emphasized.

Shell molds withstand storage better than green-sand molds do, but the best practice is to pour a shell mold not longer than 30 min after it has finished curing, one foundry expert suggsted.

Tomorrow's Heavy-Duty Trucks May Have Uniform Instrument Panels

JUST as cockpit instrument panels on future civil air transports will be standard, so will instrument panels on tomorrow's heavy-duty trucks be uniform—if SAE technical committees achieve their goals.

Nine months of concentrated effort by SAE Committee S-7 on Cockpit Standardization has resulted in a tentative agreement on standard instrument panels for air transports. (See SAE Journal, June, 1952, pp. 50–51.) And now the Instrument Panel Grouping Subcommittee of the SAE Truck and Bus Technical Committee has mapped out a proposed recommended practice for heavy-duty truck instrument panels. (See illustration.)

Basically, it has much in common with its aircraft counterpart. Both, for example, are aimed at promoting safety. (Accident records show that drivers and pilots transferring from one vehicle to another get themselves into trouble because of differences in location and operating characteristics of instruments and controls.) And both embrace more accessible and more visible instruments—properly and uniformly placed.

However, while S-7's basic arrangement includes all instruments and controls which normally appear on an air transport instrument panel, the recommended instrument panel proposed by the T&B subcommittee does not. It deals only with locations of primary instruments and controls; positions of secondary ones remaining optional.

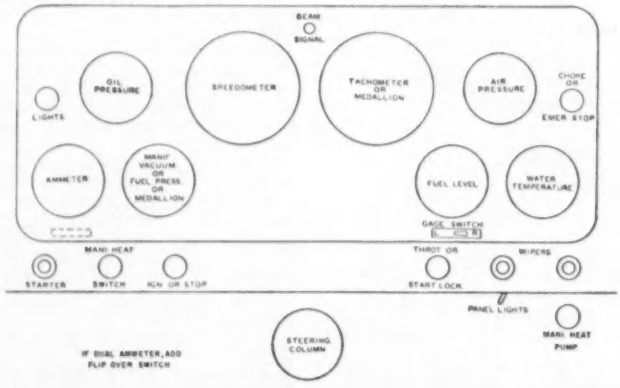
As shown in the proposed instrument panel, the subcommittee has recognized the superior position of the top row—one which the driver's eyes can "sweep across." Thus it recommends for this row those instruments which should be viewed constantly by drivers. By the same reasoning, "trend" instruments have been placed in the lower row.

It necessarily follows that size and type of instruments and controls should be considered in any instrument panel standardization program. And with this in mind, the subcommittee feels that all instruments should be of the clock type with the center point of calibration at the top of the dial.

What's more, it's felt that these types of primary controls are to be preferred:

- Ignition switch — Pull knob or key
- Normal stop control — Pull knob or T
- Light switch — Pull knob
- Starter button — Push button
- Choke — Pull knob
- Emergency stop control — Pull knob, T or loop
- Throttle — Pull knob
- Starter lock — Key
- Wiper controls — Turning knob or lever
- Panel light switch — Toggle switch or turning knob
- Manifold heater switch — Push button
- Manifold heater pump — Knob or T
- Secondary fuel gage switch — Toggle switch
- Secondary ammeter switch — Toggle switch

All of these things were tentatively decided at the subcommittee's Oct. 22 meeting in Pittsburgh, where chairman Emil Gohn, of Atlantic Refining, wielded the gavel.



Recommended practice for heavy-duty truck instrument panels under consideration by the Instrument Panel Grouping Subcommittee of the SAE Truck and Bus Technical Committee

ISTC Disbands Panel E —Miscellaneous Users

PANEL E—Miscellaneous Users, of the SAE Iron and Steel Technical Committee, is to be disbanded at the end of the 1952 administrative year.

The decision to disband Panel E was

made by the ISTC Executive Committee after a survey showed that most Panel E members preferred to transfer their participation to other panels. Panel E has been active in the past chiefly through its participation in letter ballots. Because of the varied interests of its members, there have been few projects of general concern for the group to undertake.

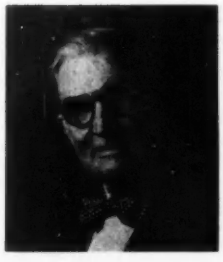
Panel E members who indicated a preference for joining other panels in replying to the questionnaire sent them July 10 have already been accepted into membership on those panels. Other Panel E members may still apply for membership on the remaining panels (Panel A—Steel Producers, Panel B—Castings, Panel C—Automotive, and Panel D—Tractor and Earthmoving).

John G. Perrin Receives Certificate

JOHN G. Perrin, retired Pratt & Whitney, engineer, now an engineering consultant, has received a certificate of appreciation from his fellow associates on the SAE Aeronautical Drafting Manual Committee S-1. The certificate was presented to him at a dinner in his honor, held at the last meeting of S-1.

In the words of the certificate, it was presented "for his important contributions in the field of technical standardization, recognizing in particular his outstanding work in aeronautical drafting manual activities."

In the presentation, his many contributions were reviewed by Gil Cole, a member of E-25 and one of Mr. Perrin's associates when he was at Pratt & Whitney.



John G. Perrin, who recently received a certificate of appreciation from his fellow associates on SAE Aeronautical Drafting Manual Committee S-1

Technishorts . . .

CABLE FOR BREAKAWAY CONNECTORS—The Conduits, Cables, and Wiring Subcommittee started work Nov. 12 on a specification for a cable to be used with the breakaway connector developed for farm tractors by the SAE Tractor Committee. Ralph Bertsche of GMC Truck and Coach Division is chairman of the Subcommittee, which is a subgroup of the SAE Electrical Equipment Committee.

INDUSTRIAL POWER TAKE-OFFS—Steps are being taken to standardize industrial power take-offs in regard to sizes of shafts and keyways and their respective locations in relation to the rear face of the flywheel housing. The work has been undertaken jointly by the Clutch Housings, Clutch Mountings, and Flywheels Subcommittee of the SAE Engine Committee and the Engine Standards Subcommittee of the SAE Construction and Industrial Machinery Technical Committee. These two subcommittees have recently worked together on revising the SAE specifications for flywheel housings and flywheels for overcenter clutches. Wesley Klatt of Waukesha Motors is chairman of the Clutch Housings Subcommittee and Trevor Davidson of Bucyrus-Erie is chairman of the Engine Standards Subcommittee.

CRIMP-TYPE TERMINALS—Crimp-type terminals for removable wiring on trucks are under consideration by the Conduits, Cables, and Wiring Subcommittee of the Electrical Equipment Committee. The present SAE Standard on Cable Terminals covers only eyelet-type terminals, spade-type terminals, and end-type starting-cable terminals.

STEEL CASTING SPEC—Is the SAE Recommended Practice on Automotive Steel Castings being used? And what, if any, revisions should be made in it? That's what Division X of the SAE Iron and Steel Technical Committee wants to know. Those who have comments on this Recommended Practice are invited to send them to Division X Chairman Gosta Vennerholm, Ford Motor Co., Room 227, Production Offices, 3000 Schaefer Road, Dearborn, Michigan.

W. F. LITTLE TO REPRESENT SAE—William F. Little of the Electrical Testing Laboratories has been appointed to represent the Society on the Committee on the Standardization of Signal Light Colors. This Committee is being organized by the U. S. National Committee of the International Commission on Illumination (C.I.E.). Little and his colleagues on the Committee will study C.I.E.'s recent recommendations on signal colors and suggest how far this country should go in adopting them.

Aero Air Conditioning Report Gets Final Touches

W. W. Reaser and W. C. Shaw

THE aeronautical information report on Air Conditioning of Aircraft at High Altitudes drew one step nearer completion at the Oct. 3 meeting of Committee A-9, Aircraft Air Conditioning Equipment. There, its author group, headed by Hamilton Standard Division's W. C. Shaw, (right) received final comments and suggestions from medical authorities and members of A-9.

Next, these recommendations will be added to the document . . . then it will be sent on to the Aircraft Accessory and Equipment Division and the SAE Aeronautics Committee for approval.

In the meantime, data are being collected so that later on a section can be added to AIR 33 which tells how to calculate:

- Cabin pressure versus time following shutdown of the cabin pressurization source.
- Relationship of bulk head blowout panel size to adjacent volumes to avoid bulk head collapse in the event of sudden decompression.

A-9 Chairman W. W. Reaser, of Douglas Aircraft, (left) will appoint a panel to prepare this appendix once sufficient data are available.

SAE Group Defining Commercial Vehicles

UP-TO-DATE, clear-cut, engineering definitions of the various types of commercial motor vehicles will soon be available. The SAE Commercial Motor Vehicle Nomenclature Committee is moving at a fast pace on this project.

Five subcommittees set up in June to review and revise the present SAE standard have already submitted their reports. And at the Oct. 21 meeting in Pittsburgh, chairman F. K. Glynn, of American Telephone and Telegraph, (below) appointed an editorial group to consolidate these reports. It's believed that the work of this group will, in turn, be completed before the next committee meeting in January.

Upon completion, this up-to-date, basic engineering information should prove useful to, among others, legislators and licensing bureaus.

F. K. Glynn

Magneto Mountings Standard Is Revised

A REVISION in the SAE Standard on Magneto Mountings has been approved recently. This revision

1. Provides that the shaft shall not extend more than 15/16 in. beyond the flange in order to leave a clearance for mating parts.

2. Adds "minimum" to the ½-in. deep dimension of the tapped hole. This change was made because deeper holes are desirable in aluminum, although the ½-in. depth is sufficient in steel or cast iron.

3. Specifies tolerances of ±1/32 in. on linear dimensions and ±2 deg on angular dimensions.

4. Brings certain other details of the drawing into conformity with the SAE Automotive Drafting Standards.

The revision was prepared by the Magneto Mountings Subcommittee of the SAE Engine Committee and approved by the SAE Technical Board. The 1953 SAE Handbook will contain the revised version of the Standard.

Set Sights on Standards For Flexible Metal Hose

"LET'S face it. A clear-cut need exists for standardization work in the flexible metal hose field," chorused 23 industry engineers at a conference held at SAE Headquarters on Sept. 24.

"There are far too many sizes of flexible metal hose and duct . . . and not even general agreement on what constitutes a hose and what a duct. What's more, performance tests and methods of testing are different for almost every manufacturer."

. . . And so it was that SAE Aeronautics Committee A-3 on Aircraft Fittings and Flexible Hose Assemblies took a new subcommittee under its wing.

This new A-3 group aims to develop a suitable specification to cover flexible metal hose and ducts. And to get things underway, Weatherhead's L. J. Henderson — A-3 chairman and temporary chairman at the Flexible Metal Hose Conference—set up two subcommittee task groups. One is to devote its attention to flexible metal hose; the other to flexible metal ducts.

To help orient these task groups, the Conference decided to classify all equipment up to and including 2 in. ID as flexible metal hose . . . equipment above 2 in. ID as flexible metal ducts. It also suggested that they begin their respective programs by making a survey of what aircraft and engine manufacturers think metal hose and ducts will be subjected to in the future.

SAE Section Meetings

December

Atlanta—Dec. 19

Belmont Steak House, Atlanta. SAE President D. P. Barnard will speak on Research—A Partner in Engineering.

Baltimore—Dec. 15

Engineers Club. SAE President D. P. Barnard will speak on Research—A Partner in Engineering.

British Columbia—Dec. 8

Hotel Georgia, Vancouver. Dinner 6:30 p.m., meeting open. Use of Helicopter in Aluminum Co. of Canada. Carl Agar, vice-president, Okanagan Air Services.

Buffalo—Dec. 9

Hotel Sheraton. Dinner 6:30 p.m., meeting 8:00 p.m. History of Niagara Frontier Industries—Frederick C. Koethen, president, Goety Petrolchemical Co. Special Ladies Night meeting. Awarding of 25-year and 35-year certificates.

Canadian—Dec. 17

Royal York Hotel, Toronto. Dinner 7:00 p.m., meeting 8:00 p.m. Subject to be announced. Speaker—George Gullen, Detroit Lubricator Co.

Central Illinois—Dec. 15

Jefferson Hotel, Peoria. Dinner 6:30 p.m., meeting 7:45 p.m. General Considerations in Camshaft Design—A. A. Goloff, staff engineer, Caterpillar Tractor Co. Requirements of Heavy-Duty Engine Oils—J. W. Vollentine, staff engineer, Caterpillar Tractor Co. Members meeting.

This is not a complete list of all Section Meetings. It includes only those meetings for which we have received sufficient advance notice to permit listing.

Chicago—Dec. 11

Hotel Knickerbocker, Chicago. Dinner 6:45 p.m., meeting 8:00 p.m. Torque Converters—for Industrial and Commercial Vehicles—W. B. Gibson, Twin Disc Clutch Co.; M. J. Waclawek, Borg-Warner Corp.; R. C. Zeidler, Borg-Warner Corp. Social Half-Hour 6:15 to 6:45 p.m. Sponsored by Twin Disc Clutch Co. and Borg & Beck.

Cincinnati—Dec. 9

Hotel Alms. Dinner 6:30 p.m., meeting 8:00 p.m. SAE President D. P. Barnard will speak on Research—A Partner in Engineering. 25-year certificates to be presented by D. P. Barnard.

Cleveland—Dec. 8

Dinner 6:30 p.m., meeting 7:30 p.m. Research Airplanes. Mr. Sandstrom, vice-president engineering, Bell Aircraft Co.

Colorado—Dec. 18

Dinner 6:30 p.m., meeting 8:00 p.m. Diesel Engine Field Maintenance. Speaker to be announced.

Dayton—Dec. 10

SAE President D. P. Barnard will speak on Research—A Partner in Engineering.

Detroit—Dec. 8

Rackham Educational Memorial Building. Dinner 6:30 p.m., meeting 8:00 p.m. Use of Plastic for Draw Dies and Related Automobile Body Tooling—George C. Adams, staff engineer, Rezolin, Inc. Dinner Speaker—Morton Neff, Altes Brewing Co.

Indiana—Dec. 11

Marott Hotel, Indianapolis. Dinner 7:00 p.m., meeting 8:00 p.m. SAE President D. P. Barnard will speak on Research—A Partner in Engineering.

Metropolitan—Dec. 11 and Jan. 8

Dec. 11—Brass Rail Restaurant, New York. Dinner 6:30 p.m., meeting 7:45 p.m. Transportation & Maintenance—A. Vance Howe.

Jan. 8—Brass Rail Restaurant, New York. Fuels and Lubricants—R. M. Cokinda.

Northern California—Dec. 17

Lucca Restaurant, San Francisco. Dinner 6:30 p.m., meeting 7:30 p.m. Aviation Flight Safety—C. M. Christenson, director of safety, United Air Lines, Inc.

Philadelphia—Dec. 10 and Jan. 7

Dec. 10—Engineers Club of Philadelphia. Dinner 6:30 p.m., meeting 8:00 p.m. Inter-Planetary Travel—I. M. Levitt, director, Fels Planetarium. Presentation of 25-year and 35-year certificates.

Jan. 7—Engineers Club. Dinner 6:30 p.m., meeting 8:00 p.m. Modern Military Helicopters—Harry S. Pack, vice-president, Piasecki Helicopter Corp. Joint Meeting: SAE-Institute of Aeronautical Sciences.

St. Louis—Dec. 9

How and Why Engine Design Affects Maintenance Costs — James Glidewell, chief engineer of Hall-Scott Motors.

Texas—Dec. 12

Use of Aluminum in Ground Vehicles—R. C. Norrie, chief engineer, Kenworth Motor Truck Co., Seattle, Wash.

Virginia—Dec. 17

William Byrd Hotel. SAE President D. P. Barnard will speak on Research—A Partner in Engineering. Ladies Night Party.

Washington—Dec. 16

Burlington Hotel. Dinner 6:15 p.m., meeting 8:15 p.m. SAE President D. P. Barnard will speak on Research—A Partner in Engineering. Presentation of 25-year and 35-year certificates.

SAE Section Meetings

Washingtonians Visit B and O Railroad Shops

• Washington Section
Allen P. Blade, Field Editor

Oct. 21—Washington Section opened the 1952-53 season with a field trip to the Mt. Clare repair and maintenance shops of the Baltimore and Ohio Railroad. The trip was followed by a dinner meeting at the Engineers Club in Baltimore.

The inspection trip, covering some 32 acres of shops for which construction began in 1832, was highlighted by explanations of operations by **Charles H. Spence**, superintendent, **Hilmer S. Bergman**, assistant superintendent, and **Russell W. Seniff**, test engineer of the Mt. Clare Shops.

Members and guests were impressed with the self-sufficiency of operations which include facilities for re-manufacture of steam locomotives, brass foundry for casting bearings and bushings, diesel engine rebuild and equipment for exacting proof test of units under load.

Bergman explained that for reasons of overall economy, steam locomotives are being replaced with diesels as rapidly as economically feasible. The time or mileage of diesel units between overhauls is extended, there is a saving in personnel and overhead expense and, more important, fewer diesels than steam locomotives are required to do the same transport work for the railroad, due to less down time of the diesel equipment.

With the advent of more diesels, fuel consumption is rapidly becoming a more reliable indicator of overhaul or inspection periods than either a time or mileage basis. When an engine uses 60 to 75 gallons of fuel per hour or about one gallon per mile, it does not take much increase in consumption of the fuel to be costly to operations. Sometimes comparatively minor repairs will correct a situation. Experience in gradually extending the time between rebuild of diesel engines has been very good, said Bergman.

Spence was the speaker at the dinner meeting. He explained that the operation of a shop, large or small, depends on much the same fundamentals to function efficiently within a limited budget. The principles mentioned were cleanliness of the shop, skill of personnel in using equipment at hand, adequate but not excessive supervision and above all the "cost consciousness" of each employee, which includes his loyalty and training. The last is a continuing job. If we are to keep abreast of changes to save money, "cost consciousness" is an important part of training, said Spence.

A discussion period followed, during which many questions were asked of the B & O Railroad hosts.

Lewis Kibbee of the American Trucking Associations was chairman of the meeting.

Jack Hulse, chairman of Washington Section, extended the thanks of the Section to the B & O for the exceptionally interesting inspection trip and briefly outlined the coming activities of the section.

Tells of Trends In Fuel Requirements

• Northern California Section
K. L. Kipp

Oct. 22—The present status and future trend of passenger car engine development, and their effects on fuel requirements, were discussed by **Gilbert Way** of the Ethyl Corp.

Way emphasized the trend towards the use of V-8 engines and automatic transmissions and its effect on octane requirement. He believes the trend towards higher power levels is reaching a peak with the probable emphasis in the future shifting towards more economy.

The effects of combustion chamber deposits on octane requirement and power were discussed, as well as the large spread in octane requirements found between cars of the same make and model. Way's opinion is that most of this spread is due to slight differences in the ignition systems of the cars involved.

Studies being conducted on spark plug fouling were also covered, as well

The B & O Railroad's Mt. Clare Shops were opened to members of Washington Section for an inspection tour on Oct. 21. At left, R. W. Seniff, engineer of tests, is shown describing the mobile diesel locomotive test set-up shown at the right

Texas Section members in San Antonio join Section Chairman Tom Collins at the head table at the first SAE technical meeting to be held in their city. Collins addressed the Sept. 22 meeting on "Modern Highway Transports." Left to right: Robert Best, Joseph Brett, Bruce Crane, Tom Collins, Norman Penfold and Eben Berry

as the development work on 12 volt and high frequency ignition systems.

SAE President D. P. Barnard, who was a guest at the meeting, presented certificates to long-time members of SAE. Seven received certificates for 35 or more years of continuous membership, and 15 for membership of 25 or more years. Past chairmen of the Section, many of whom attended, were also honored.

Ball Joints In Front Suspensions

• Western Michigan Section
A. L. Maring, Field Editor

Oct. 22—"The Application of Ball Joints to Front Suspensions" was discussed by **James H. Booth**, chief engineer, Michigan Division, Thompson Products, Inc. Colored slides were used to illustrate the talk, and displays were set up to show the use of the ball joints for suspension.

In the question and answer period, Booth was asked if the ease of steering provided by the ball joint suspension might make "power steering" unnecessary. Booth stated that the use of the ball joint suspension on a light-weight car might make power steering unnecessary, but that on heavier cars power steering would still be necessary to overcome the additional friction between the road and the tires.

The meeting was conducted by George E. Dake, Jr., chairman of the Western Michigan Section. The speaker was introduced by William Wiseman of Continental Motors.

A coffee film, "Hungry Horse Dam," was shown after dinner.

Collins Addresses San Antonio Members

• Texas Section
E. W. Berry, Jr.

Sept. 22—A group of Texas Section members in San Antonio held its first meeting with Tom Collins, chairman of Texas Section, as speaker.

During the meal 42 members and guests were entertained by three singing caballeros. At the technical session Collins spoke on "Modern Highway Transports."

More meetings in San Antonio are planned for the near future.

Reinforced Plastics Cheap, Light, Strong

• Indiana Section
V. H. Lewis, Field Editor

Oct. 16—Today's uses of reinforced plastics was the timely and interesting subject presented to the Indiana Section by **Elmer Warnken**, director of the Cincinnati Testing and Research Laboratories. After a brief historical resume of plastics and their various manufacturing processes, considerable time was devoted to the demonstration of the amazing physical properties of reinforced plastics. The fact that the yield point is in close proximity of the ultimate strength enables these materials to be stressed much higher than materials of comparable strength.

The three most widely used materials are polyester, phenolic and silicone. One of the most interesting of the many uses of the polyesters is body armor. The base materials used have been chiefly fiber glass; however, in applications where cost is a main factor, chopped fibers have been used in place of the sheet form with good results.

Reinforced plastics compare very favorably with magnesium and aluminum in slightly elevated temperature conditions. The silicone plastics are especially suitable for elevated tem-

At the Northern California Section's Oct. 22 meeting, Gilbert Way of Ethyl Corp. (right) described trends in engine development and their effect on fuel requirements. Dr. D. P. Barnard (left), who was a guest at the meeting, here chats with Section Chairman James E. Glidewell and Way before the technical session

Indiana Section Chairman R. P. Atkinson (left) chats with Elmer Warnken, director of the Cincinnati Testing and Research Laboratories, who gave Section members the latest news on reinforced plastics at the Oct. 16 meeting. Farther along the head table are H. L. Elfner, past chairman of the Section, Treasurer J. P. Leamon, and Secretary D. S. Bowman

peratures up to 400 F for extended periods. An example of the economies to be gained by the use of these materials to replace "hard-to-make" parts is an aircraft de-icing duct which cost $45.00 in stainless steel and $2.00 in laminated plastic.

Warnken pointed out that reinforced plastics are most widely used today in the aircraft and appliance industries; however, a slide brought to mind the many items of plastic to be found on the present day automobile.

During an extended discussion period Warnken answered the "sure-to-be-asked" question of plastic car bodies with both optimism and a note of caution. He pointed out that improved methods of pressure curing large sections has enabled limited production to be started by both the Glosspar Corp. of California, making custom sports car bodies, and Kaiser-Frazier Corp., which plans to produce a quantity of Henry J.'s with plastic sport bodies. Flexibility and slight distortion due to age curing are still problems in carrying the use of plastics for bodies beyond the sports car stage.

Reinforced plastics failed to make the grade in respect to bearing characteristics. The fiber glass turns in a better performance as an abrasive than it does a bearing material. Tests made in pumps resulted in completely destroyed bearings in 5 minutes of operation. However, other materials using plastics such as Teflon and Nylon are giving good performances. Further discussion revealed that plastics have good shock absorbing qualities exemplified by their "dead" effect when struck.

The paper was preceded by a presentation of 25- and 35-year membership certificates to those eligible in the Indiana Section. Ralph Teetor, Perfect Circle Co., and August Dusenberg were among those present receiving awards. A special certificate was presented to H. L. Elfner, International Harvester Co., Indianapolis Works, in appreciation of his fine work as chairman for the past year.

Transport planes are the subject of this hand-talk between M. G. Beard, who spoke on the development of the modern transport plane at the Oct. 15 meeting of Mohawk-Hudson Group and the Schenectady Section of ASME, and E. G. Haven, who introduced the speaker. Left to right are John J. Broderick, chairman of Mohawk-Hudson Group; Beard, who is chief engineer of American Airlines; Haven, manager of General Electric's aviation division, and Gardner M. Ketchum, chairman of ASME's Schenectady Section

Barnard Reviews Research Advances

• Salt Lake Group

J. P. Bywater, Field Editor

Sept. 26—SAE President **D. P. Barnard** was speaker at the first meeting of the season. Dr. Barnard was accompanied by E. W. Rentz, SAE west coast manager, who used slides to tell "The SAE Story."

Dr. Barnard reviewed the technical advances in the petroleum industry which have made an adequate supply of liquid fuels of increasingly higher quality available to the continually expanding automotive industry. The advances in both of these industries have been accomplished, to a very large degree, through the research work of the trained engineers.

There is a demand for an increasing number of trained research workers. The petroleum industry was cited as needing these researchers to keep exploration for and production of crude abreast of requirements, to develop improved refining processes and to explore alternate sources of liquid fuels. At the present time there is a critical scarcity of technically trained men and the indications are that the scarcity will exist for an indefinite time, said Dr. Barnard. The shortage is influenced by the low birth rate during the depression years, by draft into the armed services and by attraction, for personal income gains, of potential engineers away from technical training.

In a review of procedures used in exploring for crude deposits, Dr. Barnard used slides to illustrate the highly instrumentalized methods of today, which includes the Gravimeter, the seismic soundings, the magnetometer, electric logging and strata coring devices. The exploration methods used over the years have kept proven resources of petroleum ahead of de-

mands; at the present time such resources are estimated at 26 billion barrels, amounting to a 12-year reserve. Improved methods of refining and exploration can be expected to keep petroleum resources ahead of demand for many years.

An interesting color slide depicted the advances made by the refining industry in increasing both the yield from crude and the quality of gasoline. Yield has increased from about 20% of crude to the present day average of 60%. The octane quality has been improved from about 50 to present day levels of 84. The processes used to bring about these improvements, thermal and catalytic cracking, polymerization, alkylization, isomerization, and so forth, were concisely illustrated.

The refinery gate price for motor gasoline excluding taxes is about thirteen cents per gallon. Gasoline from alternate sources cannot, at present, compete in manufacturing cost with gasoline refined from crude oil. Refining technologists estimate that gasoline manufactured from shale oil would cost about 14 cents per gallon; from other sources the estimates are higher. Also, alternate sources of liquid fuels require considerably greater quantities of steel and greater capital expenditures than are required for refining crude petroleum.

Dr. Barnard concluded his talk with the reminder that a dominant factor in the future progress of the automobile and the petroleum industries is the number of technologists engaged in research and development work. Recognizing that there is today a shortage of such workers and a greater shortage predicted for the future, we should encourage the most efficient utilization of the available technically trained manpower.

At the Sept. 26 meeting of Salt Lake Group, SAE President Barnard stressed the need for more engineers to meet the needs of research for the future as well as production for the present. Seated, left to right: E. W. Rentz SAE west coast manager; Dr. Barnard; and Group Chairman Dean Despain. Standing: J. P. Bywater, Salt Lake Group field editor; Vice-Chairman Richard Ostlund; Lyle Garnas, past chairman of the Group; and Secretary-Treasurer William Littreal

Jet Transports Still on Drawing Board

• Mohawk-Hudson Group

Knud Antonsen, Field Editor

Oct. 15—It will be at least four or five years before we have commercial jet air transports in the United States, said **M. G. "Dan" Beard**, chief engineer of American Airlines, at the first meeting of the season. His topic was "Major Aspects in the Evolution of the Modern Transport Airplane."

Beard came to this conclusion after thoroughly outlining the development work and considerations behind our modern air transport systems of today and in the near future.

A good transport airplane is a compromise among five important factors: power, speed, wing area, gross weight, and payload space.

The development of the modern transport airplane got its start back in 1933 when it became apparent that there was a great need for the rapid, safe transportation of passengers and cargo which the airplane could satisfy. This led to the construction of the DC-2 type twin-engine, 14 passenger airplane, which for a number of years was of such unique character that it was hard to replace with better types. The main reason for this was the lack of aircraft engines powerful enough to haul heavier loads at higher speeds, and also the restrictions as to stalling speed set by the authorities.

However, better and more powerful engines were designed and found satisfactory in service, so it became possible to increase payload, speed, number of passengers and also to improve economy. The same type of airplane with twin engines was still being used, with practically the same wing area as before, so all improvements were obtained through redesign of fuselage, wings and tail section.

But the business volume was growing so rapidly that it soon became apparent that even larger airplanes would be needed. Not only would they have to carry more payload and passengers, but also offer more in the form of improved comfort, safety and speed. Since the airlines succeeded in getting the stalling speed regulations changed, it became possible to build larger and heavier transport airplanes than before. This led to construction of the DC-6 type airplanes powered by four engines and with a much greater passenger and payload capacity than before.

Again this type has been, and is being, used as the unique transport airplane it is. A number of important improvements have increased its capacity considerably over that of the first of its type, introduced to the public about 1947.

The next step will be the changeover to commercial jet air transports, said Beard. However, some very important factors enter the picture. We shall not in the near future expect to exceed speeds of about 600 miles per hour. The reason for this is that economy is of such importance, and we want to operate on a profitmaking basis. Above that speed, the operating cost goes up very rapidly. Also, the present wing design will not stand up at higher speeds than 600 miles per hour.

Jet powered transport airplanes are on the drawing board, said Beard; but from the time the airlines start talking about building entirely new types like this to the moment construction and tests with prototypes have been passed, four to five years can easily go by.

Balancing the five major factors that make a good transport airplane has

enabled the airlines to be the only form of transportation that has reduced fares since the war. The present average fare is running between 3.4 and 3.5 cents per passenger mile.

Beard illustrated the volume of traffic by some figures from American Airlines, which with a present payroll of about 15,000 people averages a "take-off" every 25 seconds. The regularity of schedules averages 97-99%, bad weather during the winter months in the northern part of the country contributing most to slight irregularities.

The immediate and thorough investigation combined with "grounding" of all planes of certain categories after severe accidents until the causes had been found and corrected, were also commented on by Beard.

E. G. Haven, manager, Aviation Division, General Electric Co., introduced the speaker to the joint meeting of the Schenectady Chapter of ASME and the Mohawk-Hudson Group of SAE.

Ethyl Exhibit Shows Modern Engine Complexity

• Salt Lake Group

J. P. Bywater, Field Editor

Oct. 20—Peak engine efficiency can be achieved only by good condition, quality fuels, and periodic maintenance, **Ed Watson** and **Ray Daugherty** affirmed.

Extensive pioneering research of interested technical engineering groups in the past decade has resulted in today's light weight, higher compression ratio, and economical internal combustion engines, explained Watson, who is an engineer for the Ethyl Corp.

The day of the trained ear, thin dime, and screw driver tune-up is gone. The need for trained personnel with a sound knowledge of the basic fundamentals of the machines they are servicing and the use of the necessary instruments for proper tune-up was demonstrated at a $28,000 Ethyl Corp. exhibit presented before the Salt Lake Group by Daugherty and Watson.

Five working plastic models of sectional views of the internal combustion engine were shown under black light, with several other demonstrations depicting valuable and interesting facts about automobiles, fuels and lubricants.

Long-Time Members Receive Certificates

• Syracuse Section

J. D. Cregan, Field Editor

Oct. 3—The first fall meeting of Syracuse Section was held at Sidney, N. Y., with Sidney Division Chairman W. J. Spengler presiding. Forty-five members heard **Charles Sawyer** of the Cincinnatus Auto Co. trace the evolution of the automobile from its beginning to the present.

Charles Spase, chairman of Syracuse Section, presented SAE 25-year certificates to J. T. Lansing, Herman Hanni, and T. Z. Fagan, all of Scintilla Magneto Division of Bendix Aviation Corp. Herman Hanni was absent because of illness, and his certificate was accepted for him by his son, Fred Hanni. A. J. Poole, sales and service manager of diesel products for Scintilla, was also absent, but received his 35-year certificate from Sidney Division Chairman Spase a few days later. Poole, an SAE member for 42 years, was active in organizing SAE's diesel engine engineering activity and was SAE vice-president representing that activity in 1932.

Describes Three Types Of Industrial Gas Turbines

• Southern New England Section

A. D. Nichols, Field Editor

Nov. 5—Industrial gas turbine engines will never fully replace diesel engines, but a very important place for gas turbines in industry has been established. This was the opinion of **Bruce O. Buckland**, manager of the Industrial Gas Turbine Division of General Electric Co., speaking before about 100 members and guests of the Southern New England Section at the Hotel Sheraton in Springfield, Mass.

More than 60,000 hours of running time have been accumulated by General Electric on three types of industrial gas turbines manufactured by this division. The first of the three types discussed by Buckland was the locomotive powerplant. Union Pacific Railroad now has six gas turbine locomotives in use covering approximately 10,000 miles per month. These machines use bunker C fuel oil and operate at 5.8 to 1 pressure ratio.

The second type of machine discussed was the electric power generating plant. One example of this type is the split turbine engine, in which a low pressure compressor is driven by a low pressure turbine and

Continued on Page 112

At the first meeting of the year for Syracuse Section, held Oct. 3 in Sidney, N. Y., 25- and 35-year certificates were presented to long-time members of SAE. At left, Syracuse Chairman Charles Spase presents 25-year certificates to J. T. Lansing, Fred Hanni, who accepted the certificate for his father, Herman Hanni, and T. Z. Fagan, while Sidney Division Chairman Walter J. Spengler looks on. At right, Spengler presents a 35-year certificate to A. J. Poole (right), who has been a member of SAE for 42 years and was vice-president representing diesel engine activity in 1932

SAE Student News

Chrysler Institute of Engineering

At the regular Oct. 30 meeting, the group heard **A. B. Couture**, chief experimental test engineer of the Chrysler Corp., and one of the few active original members of the corporation, recall some of the history and growing pains of the organization. Mixing some humorous incidents with some more unpleasant facts, "Tobe" told of the disastrous results of the first six-cylinder engine built for Willys, and then went on to describe the first Chrysler engine, a $3\frac{1}{2}$ by $4\frac{1}{2}$ in. six-cylinder engine with seven main bearings. Two cars were built up with these engines and put onto grueling road tests of 450 to 500 miles a day, without stopping, until 35,000 miles had been covered. The cars were torn down and inspected with no signs of serious wear, so they were put back onto the road immediately.

The real test of a car then was whether or not it could climb Fort George Hill in high gear with five passengers. Couture drove up this hill from a standing start, reaching the top at 29 mph. Several years later, a copy of this car, in the hands of William Durant, was tested at only 14 mph on the same test. Couture was called in to restore the car to its former performance. It took only a few blocks for him to discover that due to faulty geometry the brakes were being applied every time the car hit a bump. Once the brake cables were relaxed good performance was restored, and the Chrysler engineers had a consulting job.

Further refinements in the original engine resulted in a $3 \times 4\frac{3}{4}$ in. engine with the unheard-of compression ratio of 4.5 to 1 and an unbelieveable top speed of 3600 rpm. This engine went into production on the first Chrysler car along with four wheel brakes, then a sports car luxury item. With a higher compression ratio and a little modernization, he ventured that this engine would compare favorably with today's L head sixes.

—**Gene Cowle**, Field Editor

The Pennsylvania State College

The Penn State Student Branch held its first meeting as an officially recognized Branch on Oct. 29. Previously it had been a Student Club for three years.

R. H. Fritzges of the Mack Manufacturing Co. spoke on "Total Control with Power Hydraulics." The talk was based on his experience with the development of a "one-pump" hydraulic system for the operation of accessories, including power steering, brakes, doors, windshield wipers, and ventilation controls. Primary emphasis was given to the use of this system on buses, since this is where it is now being used. He said that over 400 urban buses, most of them in the New York City area, have been built with the system and put into use.

He then went on to describe the system. It uses a direct drive oil pump which takes oil from a reservoir and pumps it into a receiver which contains a nitrogen-filled rubber balloon. This receiver maintains a reserve of oil under a pressure of 1000 psi, so that the pump must maintain a pressure head only a small part of the time. Pump operation is controlled by a check valve. From the receiver oil is piped to the necessary accessories and their controls.

Fritzges then described the accessories which are operated from the oil in the reservoir, illustrating with cutaway models, charts, and slides. One of the models was a cutaway power steering unit which is made an integral part of the steering linkage, thereby permitting close control at high speed. Other accessories were designed to replace those now powered by air. They had the advantage of smaller size, weight, and fewer maintenance requirements

Possible future applications mentioned were hydraulic starting motors and truck accessories such as dump lifts. After his talk, Fritzges answered questions about the system.

—**Joseph K. Thornton**, Field Editor

New Officers at Northrop Aeronautical Institute

New officers and faculty adviser of the SAE Student Branch at Northrop Aeronautical Institute are, left to right, Vice-Chairman Joseph E. Stengel, Chairman Earl J. Dieckman, Faculty Adviser Kenneth Strite, Secretary Joseph F. Downey, and Treasurer Douglas Baker

Fenn College

Members of the SAE Student Branch at Fenn assembled Nov. 5 for a well-conducted and informative tour of the Pitney Glass Works, a General Electric Lamp Division, in Cleveland.

The tour provided a detailed examination and explanation of the mechanical, chemical and process features peculiar to the production of glass "envelopes" for incandescent lamps. At an informal meeting after the tour, Plant Manager Cahlsen elaborated on the technique of frosting the bulbs.

Students were especially impressed with the high production per employee and the standard of quality maintained at the plant.

—**Charles B. Goldman,** Field Editor

California State Polytechnic College

George Green, formerly of General Electric, and now an instructor in the Mechanical Engineering Department here at Cal Poly, talked of the testing of jet engines at the second meeting of the Cal Poly student chapter of the SAE on Oct. 13. Green said that the tests were divided into two categories: the production line tests, and the development tests.

Production tests are carried out on all jet engines that come straight from the production line. The procedure is to take the "green" engine from the production line, subject it to the test program that is set up by the branch of armed forces that will receive the engine, disassemble the engine and correct its defects, and put it through a final test before releasing it. All production line jets are thoroughly tested because the jets are very costly, they must satisfy the armed forces, and a life may depend upon the proper function of a jet regardless of conditions.

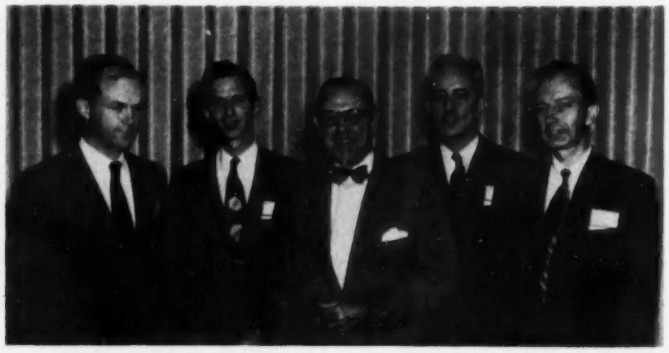
Development tests are for the purpose of trying new ideas and design. The programs for these tests are set up by the engineers behind the developments. Every new idea or design is given a thorough run-down in the test cells before it is rejected or accepted.

The test cells used by General Electric engineers are designed with a large air intake duct at the front and an exhaust duct to the rear. A belt of concrete around the center of each cell protects the test crew from flying debris in the event of an impeller, or other type of structural failure. General Electric also employs unique methods and equipment designed for fast installment and removal of jet engines in the test cells.

Green stated that such extensive, thorough testing results in the solving of many troubles and problems found in jet engines.

Oron Palmer, Field Editor

Pedagogic Pentad



This professorial group chatted about the problems of training engineers at the recent SAE National Transportation Meeting, in Pittsburgh. They are (left to right): Dr. W. F. Stokey, Carnegie Institute of Technology's mechanical engineering department; Prof. N. H. Wackenhut, faculty adviser to the SAE Student Branch at the University of Pittsburgh; SAE Past-President R. J. S. Pigott, Gulf Research & Development, who was professor of steam engineering at Columbia University from 1912 to 1915; Dr. N. Lewis Buck, head of the department of mechanical engineering at the University of Pittsburgh; and Dr. D. W. Ver Planck, head of the department of mechanical engineering at Carnegie Institute of Technology

"SAE Then" was represented at the Reunion Day parade at the University of Saskatchewan by this 1907 Russell touring car. A 1951 Ford proudly bore the sign "SAE Now." The Russell was loaned to the SAE Club at the University by the Western Development Museum

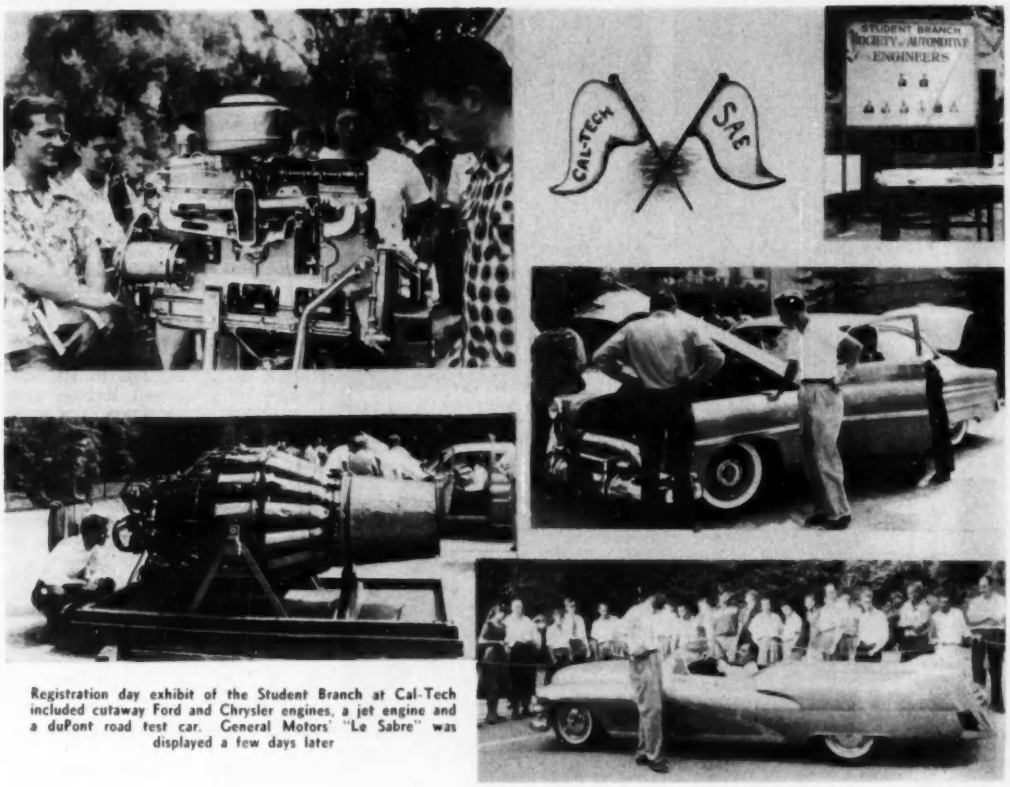
University of Saskatchewan

The opening meeting of the SAE Student Club was held in the Engineering Building on Oct. 16. Thirty-five turned out for the meeting, accounting for 10 new SAE members. A film entitled "A Tractor is Born," showing the design and development behind the new Fordson Major tractor, was shown to the group.

The annual Reunion Day Parade of the University of Saskatchewan was held in downtown Saskatoon on the morning of Oct. 18. The SAE Club entry in the parade illustrated the progress which has been made in automotive engineering because of the SAE. The entry consisted of a 1907 Russell Touring Car, borrowed from the Western Development Museum, and a 1951 Ford, in contrast.

—**Vern Elliott**

SAE Exhibit at California Institute of Technology



Registration day exhibit of the Student Branch at Cal-Tech included cutaway Ford and Chrysler engines, a jet engine and a duPont road test car. General Motors' "Le Sabre" was displayed a few days later

California Institute of Technology

The SAE Student Branch at California Institute of Technology started off the new term with an impressive exhibit on Registration day. A cutaway Ford OH-6 engine, a cutaway Chrysler V-8, a large jet engine, and a duPont road test car were on display, as well as material on and publications of SAE. Forty-five new members were enrolled in the Student Branch.

On Oct. 2, General Motors' revolutionary sports car, "Le Sabre," was exhibited and explained to Student Branch members. Bill Wright, a Cal-Tech graduate student in metallurgy, gave a talk on titanium.

The next week's meeting, on Oct. 9, was a shop training class in gas and arc welding. The Student Branch stresses such classes to give members training in practical shop techniques.

The next week student members enjoyed a dinner meeting with Southern California Section, and a week later heard SAE Past President James Crawford describe the "Development of the Automotive Industry."

Speakers, films or shop training classes are scheduled for each Thursday night. Among the programs planned is a panel discussion by engineers and engineering economists giving a "blow-by-blow" description of the history of an engineering product.

Chairman Walt Eager and Secretary Al Goldman are assisted in enrolling new members by house chairmen for each of the four residences and chairmen for graduate students and for off-campus students. Under the guidance of Faculty Adviser Peter Kyropoulos, the Student Branch continues to grow, and enrollment is soon expected to hit the 100 mark.

—**Walt Eager**

New faculty advisers at Student Branches this year include:

- **Dr. Martin A. Elliott** of the Mechanical Engineering Department at Illinois Institute of Technology.
- **James G. Lewellen**, assistant in the Aeronautical Engineering Department at Parks College. Lewellen served as secretary of the SAE Student Branch when he was a student at Parks.
- **John D. Simmonds** of the Department of Mechanical Engineering at the University of Florida.
- **E. B. Reynolds**, assistant professor in the Mechanical Engineering Department at the Pennsylvania State College.
- **C. A. Besio**, assistant professor of mechanical engineering at Southern Methodist University.

Own or Lease Vehicles? Clevelanders Debate . . .

Continued from Page 108

J. N. Bauman (left) emphasized that cost per unit delivered, not initial cost, should be the criterion for truck selection. Bauman's coffee talk at the Oct. 13 meeting of Cleveland Section was followed by a symposium on owning and leasing vehicles, moderated by Samuel J. Lee (right), vice-chairman of transportation and maintenance activity

Panelists Robert Gardner and Harry Mathews and T. J. Durkin, transportation and maintenance activity chairman of Cleveland Section, listen to Howard L. Willett, Jr., list advantages of long term leasing

Cleveland Section Chairman Robert G. Cummings welcomed the crowd. Left to right: panelists E. C. Pratt, W. Howard Amor, and Howard Willett, Jr., T and M Chairman Durkin, and Section Chairman Cummings

the load and high pressure compressor driven by a high pressure turbine. Each compressor has a pressure ratio of 3 to 1, making a total pressure ratio of 9 to 1. Air from the low pressure compressor passes through an intercooler before entering the high pressure compressor. Several slides of this type of machine, taken in various parts of the country, were shown.

The third engine Buckland described was the general service machine. Some engines of this type are used for pipe line pumping. Natural gas is often the fuel used in this application. Buckland said that some turbines using natural gas as a fuel have run as long as 25,000 hours with little or no maintenance.

Some of the many problems of gas turbines which have not yet been fully solved are life of seals and bearings, failure of buckets due to vibration, failure of welds and turbine wheel rims, life of burner liners. One major problem is the short life of nozzles and buckets due to the corrosive action and ash deposits from bunker C fuel oil. Buckland feels that choice of alloy alone will not answer the corrosive problem, but that a fuel oil modified with additives will increase the life of these parts.

Debate Pros and Cons Of Owning versus Leasing

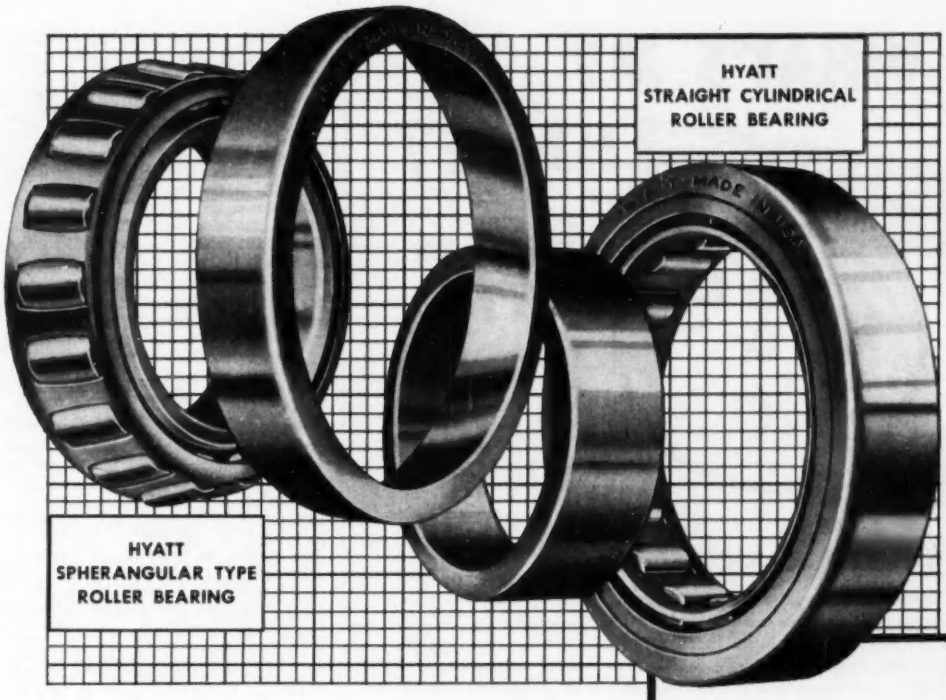
• Cleveland Section

W. B. Fiske, Field Editor

Oct. 13—Attracting fleet operators from far and near as well as local members of the Cleveland Section, the October meeting at the Lake Shore Country Club was devoted to a symposium discussion of one of the livest subjects of the day—"Leasing versus Company Ownership of Motor Vehicles." Five national authorities in the field formed the panel that discussed the problems and the advantages found in each phase of operation.

Cleveland Section Chairman Robert E. Cummings welcomed the large crowd and turned the program over to Transportation and Maintenance Activity Chairman **T. J. Durkin** and Assistant Chairman **Samuel J. Lee**. The latter was moderator of the panel discussion.

Preliminary to the panel session, Coffee Speaker J. N. Bauman, vice-president in charge of sales of White Motor Co., talked briefly on "Trends in Motor Truck Transportation." Bauman pointed out that for years manufacturers have devoted their energies to mechanical progress, but that



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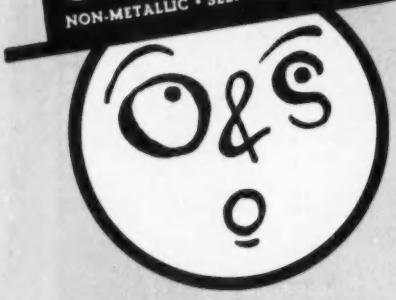

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the biggest consideration today should be utility. In these days of high costs, trucks must be measured in terms of how much they can do, and operations must be measuured on the basis of cost per unit of delivery. In the final analysis the only real cost that counts is the cost per delivery, and efficiency must be measured against this yardstick.

The cost of a truck in city delivery is about $25 to $30 per day, said Bauman, whether that truck made many deliveries or not. The cost goes down per unit of delivery as the number of units delivered goes up. The ability to produce, rather than the initial cost of a vehicle, is the important thing.

The Panel Discussion

In the symposium on leasing versus company ownership, the opening speaker, Robert Gardner, manager of transportation, Lever Brothers Co., offered his own company's experiences to indicate the advantages of company ownership of automobiles. He pointed out that a large organization, with enough vehicles traveling enough miles, can better afford to run its own fleet on an efficient and closely controlled basis.

Gardner brought out figures to demonstrate cost advantages that had accrued to his own company, and he answered the advantage claims of leasing companies. There definitely is a place for leasing, he said, but principally with the small fleet operators. His discussion was mainly concerned with the automobiles used by company salesmen.

Howard L. Willett, Jr., president of the Willett Co. and president of the National Truck Leasing System, explained the three kinds of bonafide truck leasing—daily rental, long term leasing, and long term finance leasing, none of which should be confused with "trip" leasing as used by over-the-road haulers.

Willett pointed out that there are eight distinct advantages to be derived from long term leasing:

(1) It saves the valuable time of executives.

(2) Costs are known in advance.

(3) It eliminates maintenance worries.

(4) It releases capital for other things.

(5) You get smart, well-kept vehicles painted with your name and advertising in your own colors.

(6) There is continuous service with replacements for any disabled trucks.

(7) Peak period service assures the operator of enough vehicles.

(8) It knocks out competition.

E. C. Pratt, general manager, Fleet Leasing Corp., contrasted the advantages of passenger car ownership with

leasing, indicating a benefit for most companies from the latter. In the case of leasing there is no capital investment, the entire cost is deductable, costs can be budgeted in advance, tax problems are eliminated, there are no maintenance costs, and uniformity can be assured. He pointed out that leasing, though still in its infancy, is here to stay.

Harry O. Mathews, manager of transportation and distribution for Armour and Co., showed that his company favored ownership of the passenger car fleet because they could operate more economically than they could lease. Like other large companies, they are able to purchase at a price equal to, and sometimes better than, the leasing company, and there is no other reason, other than invested capital, why they should lease.

Leasing Rates for Distribution Trucks

In the case of distribution trucks, he said, it is a different story. The trucks range in three sizes from 14,000 to 22,000 lb. gross vehicle weight, and are equipped with insulated, refrigerated bodies that often cost more than the truck itself. This presents a real problem for a leasing company in calculating rates that are not excessive. In several cities the company leases its trucks on a satisfactory basis, but in other cities the rates quoted are up to 100% higher. Leasing rates would be more attractive if the high garage costs were eliminated in favor of outdoor storage.

The company also leases some of its over-the-road equipment, with much to be gained from leasing. Each new operation is analyzed from a leasing standpoint before any equipment is purchased. He gave his opinion that the company would lease more of this type of equipment than it owned in the future.

W. Howard Amor, vice-president, the Cleveland Cartage Co., and vice-president, Trucklease, Inc., weighed the merits of ownership and leasing from experience in both fields. Although leasing is not the answer to every problem, there is no question but that it performs a real service, he said. To date it has not been fully understood. Leasing is ideal in cities where good service is available, and it meets the requirements of the operators from every standpoint. Clean, well-maintained trucks are assured, and many of the problems of truck ownership are eliminated.

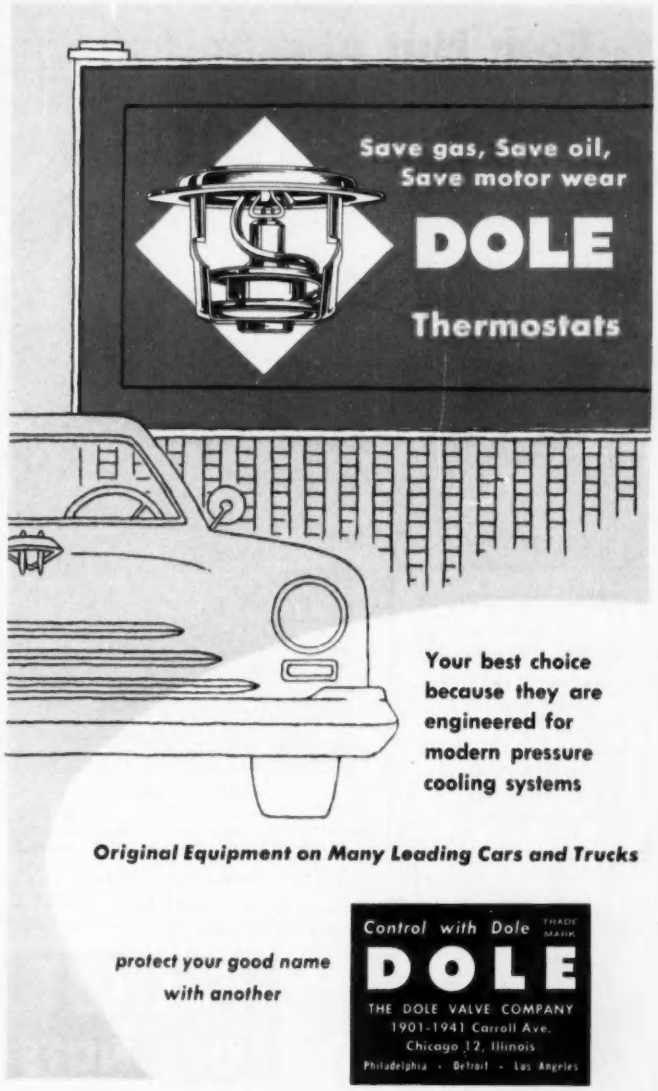
The panel discussion was followed by a lively question-and-answer period in which the viewpoints of each side were challenged. No definite decision was reached other than that the advantages of leasing versus ownership should be carefully weighed by each company in line with its own operations. The steady increase in leasing was emphasized.

Standardization Key To Rapid Mobilization

• Central Illinois Section
R. F. Hughes, Field Editor

Oct. 20—Approximately 125 members of the Central Illinois Section listened to **Lt. Col. D. G. Hammond**, chief of research and development, Corps of Engineers, U. S. Army, discuss "The Problems of the Modern Minute Man" at the Springfield Works of the Allis-Chalmers Mfg. Co.

Colonel Hammond referred to the combination of the armed forces backed by the productive capacity of American industry as the modern minute man. He drew a brief contrast between the problem of rapid armament in 1775 and the present time. Now, a million ready men are not enough, overnight is too long, and the present-day arms are so complex that they are not available in the house-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hold. Nevertheless, the need for readily available men and arms is now greater than ever before

One of the greatest problems facing the military procurement people during time of emergency is that of standardization of parts and machines. To utilize the productive capacity of industry efficiently, the Defense Department needs to use machines of commercial design with a minimum of military modifications. As each manufacturer has little interchangeability of parts with his competitors, the armed forces must keep complete stocks of similar parts for each brand of machine they use.

The Colonel pointed out that prior to a recent attempt at standardization, there were 10 different cylinder bore sizes between 2⅞ in. and 4½ in. available in gasoline engines which used 126 different pistons. Through a concerted effort by the armed forces and manufacturers, the number of cylinder bores were reduced to five and the number of pistons were reduced to nineteen.

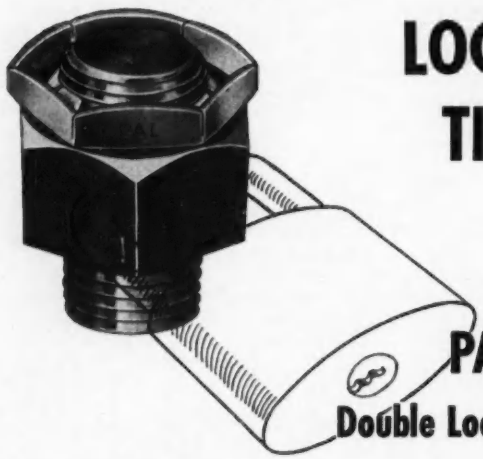
In conclusion, Colonel Hammond stated that we must find a solution to the problems of rapid mobilization if we are to survive any great military emergency.

John T. Liggett, chairman of the Central Illinois Section, introduced the after-dinner speaker, George Cashman, custodian of Lincoln's Tomb at Springfield. Cashman traced the history of Lincoln's tomb from its organization in 1865 to the present date.

R. V. Larson, secretary of the Section, presented framed awards to four members who have been SAE members for 25 or more years. They were: Samuel W. Gray, John W. Hobbs, John T. Liggett, and Emil F. Norelius.

H. H. Bidwell was the technical chairman of the meeting.

Both Nut and Bolt are



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Gives Rules For Brake Care

• Colorado Group

Robert F. Brown, Field Editor

Oct. 16—**Ed Cody**, service manager of the Grizzly Mfg. Co. of Paulding, Ohio, presented a talk on heavy-duty brake materials, illustrating his points with slides.

After briefly explaining how brake block and lining materials are made and tested, Cody clearly showed the fundamental relationships existing in the transformation of the kinetic energy of motion into heat energy during the braking process. A large part of the talk was devoted to maintenance, and the audience was left in no doubt as to what constitutes good brake maintenance practise.

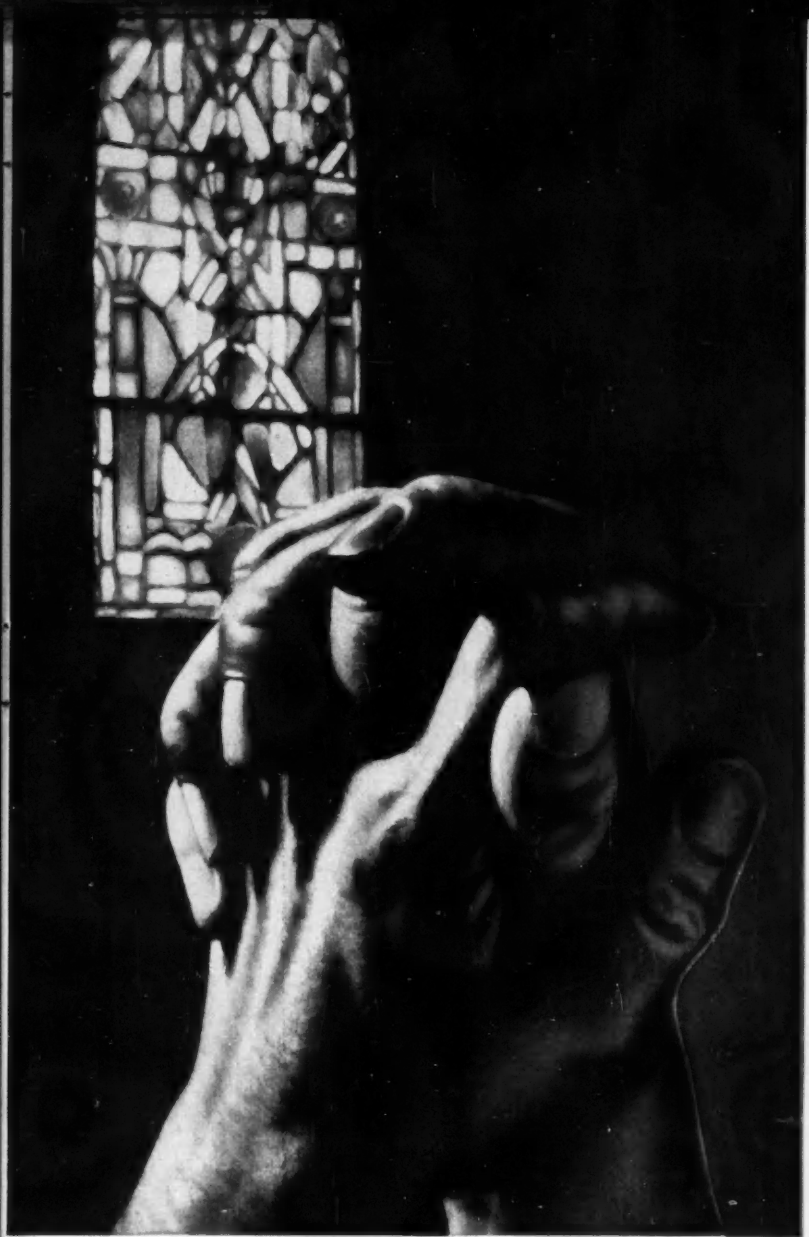
The talk was followed by a short discussion period, mainly on specific brake problems.

Tour Aero Division Of Minneapolis-Honeywell

• Twin City Section

D. D. Hombeck, Field Editor

Nov. 12—On Wednesday evening, the Twin City Section made an inspection trip of the Aeronautical Division of Minneapolis-Honeywell Regulator Co. Members attending saw the engineering, test and production facilities, employing 4000, that are used to produce Honeywell gyroscopes, auto-pilots for bombing, jet fighter airplanes and helicopters, and fuel gage measuring sys-



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tems, as well as many classified control devices.

Throughout the tour members were impressed with the accuracy and precision of the various operations. Honeywell maintains special gyro laboratories that are as clean as hospital rooms. In the test department, SAE members were shown some 25 different testing areas and devices. These included vibration and humidity rooms, salt spray, fungus, and sandstorm chambers, jet fuels laboratory, hydraulics laboratory and radio noise rooms.

Altogether the group toured three buildings covering 340,000 square feet. Prof. B. J. Robertson, emeritus, formerly of the University of Minnesota mechanical engineering staff and now consulting engineer with Honeywell, handled arrangements that made this tour possible. Professor Robertson is also chairman of the Twin City Section of the SAE.

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Name Causes Of Engine Wear

• Metropolitan Section
C. F. Foell, Field Editor

Oct. 16—The ever-present, ever-provocative subject of engine wear was reviewed from all angles at Met Section's October dinner meeting. **Max M. Roensch** of Ethyl Corp., functioned as moderator for a three-part presentation of the subject by **John F. Kunc, Jr.**, Esso Laboratories; **Dr. J. C. Geniesse**, Atlantic Refining Co.; and **Robert J. Pocock**, Ford Motor Co.

All speakers agreed that the point of "too-much" wear is reached when oil consumption becomes excessive and, to a lesser extent, when power output drops off. It is at such times that engines are brought in for rebuilding. No two speakers seemingly could agree thereafter on the relative positions of the principal causes of wear. Kunc, Geniesse, and Pocock individually allocated the principal credit, or blame, to friction, corrosion, and abrasion, respectively.

Kunc, speaking also for co-workers D. S. McArthur and L. E. Moody, gave the highlights of a combined field and laboratory project showing, first, that wear is the reason engines are overhauled, and second, that friction—the rubbing contact of opposing surfaces—is responsible for most engine wear normally.

Laboratory engine tests under deliberate and separate frictional, abrasive, and corrosive (low engine temperature) conditions supplied typical ring surface effects which were used to identify the ring conditions observed in engines being overhauled in commercial garages and rebuilding shops. Friction-worn surfaces are comparatively smooth; abrasion-worn surfaces are ridged and scored; while corrosion-worn surfaces are rough and unevenly pitted.

Kunc conceded that low-temperature corrosive wear can be much more severe than frictional wear, but emphasized that careful analysis of the wear patterns of field engines failed to show corrosive wear as the chief contributor to total engine wear. This was true even when corrosive wear conditions were encouraged—that is, start-stop operation of a fleet of light delivery trucks over an extended period, with overnight parking out-of-doors in the winter. Friction, supplemented by abrasion, is the chief culprit, maintained Kunc.

In developing the corrosion theme, Dr. Geniesse cited early experimental work showing dissolved carbon dioxide to be one possible source of heavy cylinder and ring wear. He also mentioned some of the difficulties of the older attempts to study wear, namely the time and labor consumed in tracing down wear and then in securing

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quantitative data by weighing and measurement. He credited new radioactive techniques, using "hot" irradiated parts, with greatly speeding up wear-determination work, with the accuracy of the older conventional methods maintained or even improved.

Results of numerous tests were given to demonstrate that corrosive wear increases very rapidly as engine cylinder wall temperatures drop below 150 F. The corrosion products resulting from those low temperatures are rapidly worn off the parent surfaces, presenting fresh metal to further rapid attack by water and acids. Dr. Geniesse listed the important variables affecting corrosive wear rates: atmospheric temperature, trip length, fuel and fuel sulphur, air-fuel ratio, lubricating base oil and additives employed. Corrosive wear tendencies are pronounced with low atmospheric temperatures, short trip mileage and start-stop driving, high sulphur, high (lean) air-fuel ratio. Oils of high detergency level can greatly offset corrosive wear tendencies, but all such oils are not equally effective. Where additive oils are suitable to specific sets of conditions, they have shown excellent corrosive-wear reduction possibilities. The speaker expressed confidence that low-temperature corrosive wear need not be a problem if lubricating oils are properly selected and further, if jacket temperatures are held to reasonably high levels, at least to 150 F.

The abrasive wear studies discussed by Pocock centered on various Ford fleets and employee cars, the individual units of which were used in and around Detroit; each unit was observed for about a 20,000-mile period. The speaker ascribed engine wear as due in a large measure to the presence of solid contaminants—dirt, metal particles, casting sand, hard carbon, lead salts from combustion—and their possible circulation in the oil stream.

Oil-Bath Air Cleaners

Oil-bath air cleaners are reported to be about twice as effective as the oil-wetted type in holding down wear. Full-flow oil filters are superior to by-pass filters. The primary burden, however, apparently lies with the air cleaner and its ability to deliver clear air to the engine—dirt has to pass down the cylinder walls only once to produce considerable wear. Pocock stated that upper cylinder wear is primarily of the abrasive type, lower cylinder wear of the friction type.

Prior to the floor discussion Roensch pointed out that internal-combustion engine cylinder conditions are intrinsically favorable to wear. Boundary-film conditions prevail most of the time, making the surfaces extremely susceptible to attack from all sources of wear.

This meeting was arranged and conducted by Robert M. Cokinda, Met Section vice-chairman for fuels and lubricants.

Describes Cummins Diesel

• Southern California Section
P. Kyropoulos

Oct. 16—Southern California Section started its 1952-53 activities with a very well attended meeting. The subject was "Development and Application of the Horizontal High-Speed Diesel Engine for Automotive Installations." The speaker was **C. Raymond Boll**, manager, engine sales, Cummins Engine Co.

Boll briefly discussed the development of Cummins horizontal diesel engines and their application to trucks, buses and rail cars. He described the development and application of an experimental high-speed, high output turbo-charged horizontal diesel engine which was installed in a race car entered in the 1952 Indianapolis race.

A short movie showed the design and use of the Cummins race car.

Light Metals In Car of Future

• Chicago Section
D. J. Schrum

Oct. 14—The story of "Light Metals in the Car of the Future" was given to 250 members and guests of the Chicago Section by **J. H. Dunn** of the Aluminum Co. of America. Using a novel form of presentation, Dunn built up on the stage the skeleton of "the car of the future" using aluminum and magnesium components, with a discussion of fabricating methods and qualifications for the proposed components. He pointed out that, although some of the proposals might seem visionary and fantastic, the aim is to do the job better for less cost.

The engine was built with brazed aluminum cylinder block and head. By dividing the castings into simple sections to be cast in permanent molds and brazing them together, expensive cores are eliminated with the assurance of smooth and clean water passages which are easily inspected during manufacture. Using only three patterns, a cylinder block for a V-4, V-6, or V-8 engine can be produced by adding sections. Manifolds were also produced using this "sandwich" brazing method.

As in most of the cars of today, aluminum pistons were used. Aluminum was used for bearings, carburetor parts, water-pump body, and timing gears. The problem of noise in the timing gear was eliminated by the interesting expedient of cutting a

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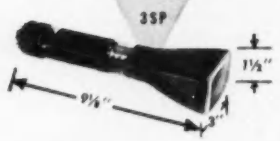

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groove in the gear and inserting a steel snap ring to damp the vibrations. The oil pump housing takes advantage of the low cost and high machining speeds of magnesium castings.

The requirements of the radiator are being met by the aluminum industry. Availability and price makes it competitive with copper, which has always been accepted. The problems of fabrication and corrosion resistance have been solved by the development of laminated materials with corrosion-resistant alloy on the inside of the tubes, brazing alloy on the outside of the tubes and a high-strength alloy for core to give the radiator mechanical properties to stand up in the car. The problem of repair methods has not been solved but probably will be with development of a plastic solder of some sort.

In the electrical system, wire with the proper conductivity, as well as flexibility and resilience, has been developed together with the necessary solder and flux for attaching either copper or aluminum terminals. The soldered joints are protected from corrosion in moist environment by plastic coating or wrapping.

Plaster casting makes it possible to cast torque converter parts with back drafts or re-entrant sections, which no other casting process can produce. Close dimensional tolerances and smooth surface finish are maintained. Die casting and welding or brazing have also proved successful methods of producing torque converter parts.

In general, aluminum die castings have not been used for stressed parts; but the aluminum die-cast clutch housing has demonstrated that proper design can produce a part that, in comparison to a permanent mold casting, is 25% stronger in shear, 10% stronger in bending, 100% better in fatigue, 15% lower in cost, and 25% lower in weight. Service experience proves that die castings may be successfully used for this application.

Aluminum in disc brakes has been shown to have superior cooling qualities. Brake master cylinder and piston for the proposed car were cast aluminum. For the brake lines a 4S0 alloy tube is used and competes costwise with solid copper but not with steel.

Prospects for complete aluminum bodies are somewhat dim, but the use of aluminum doors and similar parts, where weight reduction is desirable from an operator's standpoint, can be foreseen. A weight saving of thirty pounds per door can be obtained with aluminum.

The decorative qualities of the anodic finishes, both bright and color-dyed, are of importance for future body interiors. The attractiveness of these finishes has a special appeal to the women who influence the majority of car sales.

The significant trend to light metals is shown by the fact that the General Motors car of the future proposed in 1938 was all steel with practically no light metals, while the 1948-49 version

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was constructed mostly of aluminum and magnesium. Thus, during the next twenty years, as light metals prove to do the job better or cheaper, it is predicted that instead of the present fifteen to twenty pounds of light metals the car of the future will use nearly two hundred pounds.

M. P. deBlumenthal, chief research engineer of Studebaker and Vice Chairman of Passenger Car Activity, was chairman of the meeting.

Outlines Problems Of Supersonic Craft

• Williamsport Group

Paul Cervinsky, Field Editor

Nov. 3—Successful supersonic aircraft and flight is dependent upon engine design and configuration, stated **Stanley Smith**, chief airplane engineer of Bell Aircraft, before 57 members and guests of the Williamsport Group.

Although the XS-1 has been flown and accepted by the Air Force and is considered past history, the problems and obstacles encountered and how they were solved are very worthwhile.

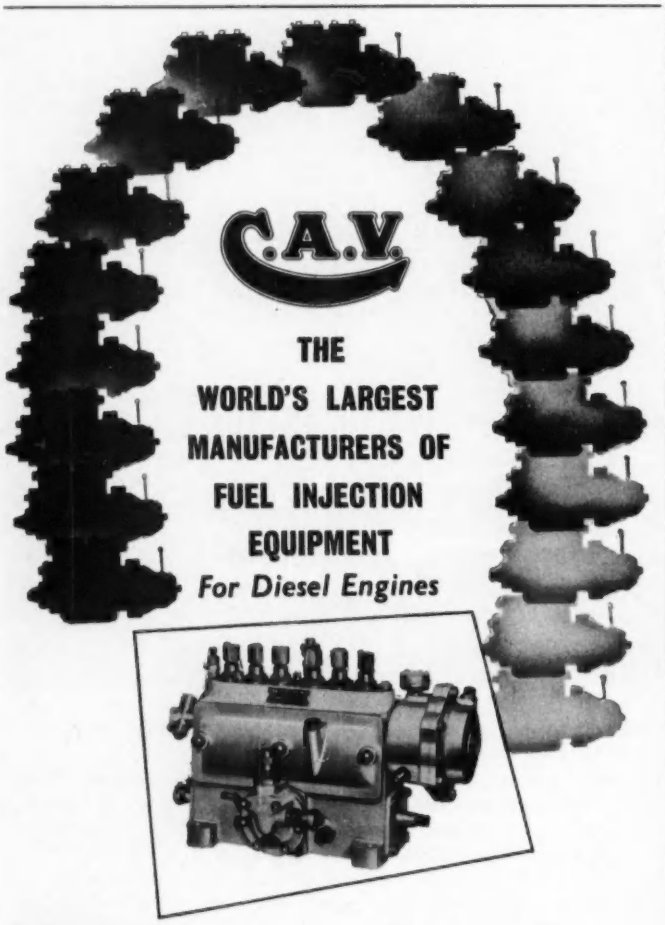
The total weight of the XS-1 is 13,000 lb, the fuel itself weighing 8000 lb; this results in a wing loading of 100 psf. It requires 327 hp to pump the 1600 gal of fuel to maintain the XS-1 in flight for 2.8 min.

The experience gained in building the XS-1 will enable Bell Aircraft to construct and fly the XS-2, which is much larger and faster.

The main problems arising in the supersonic aircraft field are:

1. Supplying the tremendous power needed to overcome extreme drag.
2. Controlling surface movement and sha ..
3. Thinning wings and related surfaces sufficiently.
4. Using fuselage shape and size to best advantage.
5. Ventilating the engine compartment.
6. Fuel supply problems.
7. Safety devices for the pilot.

A short discussion period was followed by the showing of two films of the XS-1.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Improvements In Retreading

• Baltimore Section

C. H. Williams, Field Editor

Oct. 9—"Pre-stretching of tread material increases life and reduces separation tendencies of retreaded tires," stated **Charles P. Raney**. Raney, who represents the Paul E. Hawkinson Co. of Minneapolis, an organization specializing in tread servicing, illustrated his point with photos taken during roll tests of retreaded tires.

Tires retreaded by the conventional practice of wrapping the material around the carcass exhibit a pronounced "pile-up" of rubber ahead of the contact point when rolling under load. The resultant work heats the material to temperatures sufficiently high to reduce service life and to weaken the bond. The Hawkinson method of forming the tread material into a slightly undersize ring and subsequently stretching it to permit insertion of the tire carcass effectively eliminates this deformation of the rubber and results in operating temperatures no higher than those encountered in new tire operation.

Further improvements in the service life of retreads is obtained by bonding the tread material directly to the car-

U·S·S Carilloy steel springs soak up 8 million lb.-ft. Torque!

Alloy springs cushion tremendous mechanical shocks in 200-ton short-circuit generators ... save expense of forgings

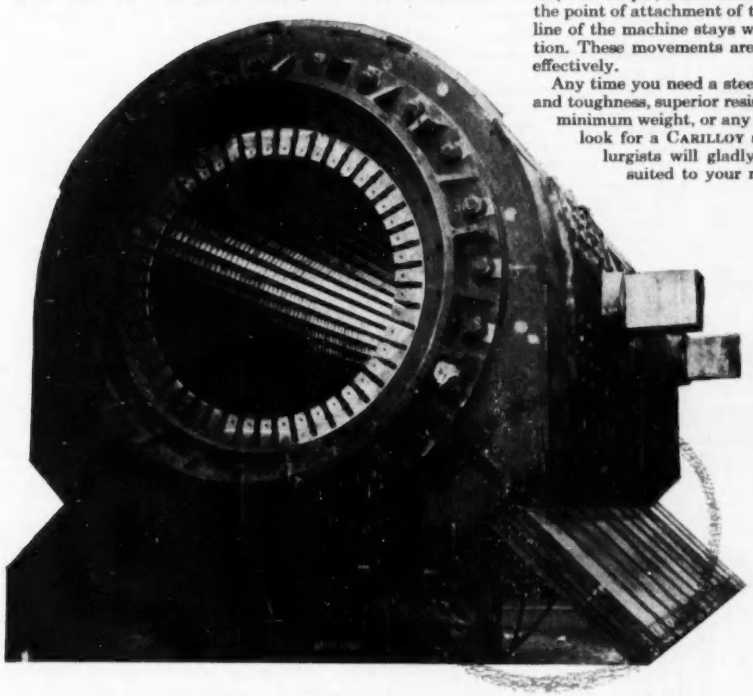
● In testing high-voltage circuit breakers, engineers at General Electric Company *intentionally* short-circuit two huge motor-driven generators. Each of these test generators is normally rated 125,000 kva, but provides short-circuit currents as high as 182,000 amp, instantaneous peak of the offset wave, corresponding to about 1,625,000-kva rms symmetrical short-circuit duty. Such operation causes tremendous mechanical stresses to build up inside each machine. These stresses create a torque that tries to twist loose the 200-ton stator assembly.

But no damage is done! These powerful machines are mounted on U·S·S CARILLOY steel plate springs that cushion the shock and then damp out any vibrations that follow. The springs must absorb these terrific shock torsion loads as often as 40 times an hour; so a tough, very durable steel is needed.

Forged springs were considered first. But GE engineers, with the cooperation of United States Steel metallurgists, found that a rolled alloy steel, U·S·S CARILLOY 4340, provides the required mechanical properties at *much lower cost*. This steel is tough, even though extremely hard, and it assures good endurance at 40,000 psi. as required in this application. In addition, it is easy to heat treat.

This CARILLOY steel is giving excellent service. Under the most severe short circuit, developing a whopping *8 million lb. ft.* of torque, frame rotation is about ½ in. each way at the point of attachment of the springs. And the axial centerline of the machine stays within 30 mils of its normal position. These movements are sufficient to cushion the shock effectively.

Any time you need a steel that will provide high strength and toughness, superior resistance to shock and torsion with minimum weight, or any combination of these properties, look for a CARILLOY steel. Experienced U·S·S metallurgists will gladly help you choose the one best suited to your requirements.



At General Electric Company's new switchgear development laboratory, this 1,625,000-kva short-circuit test generator is protected from mechanical damage during short-circuit tests by plate springs made of U·S·S CARILLOY steel. Rolled CARILLOY 4340 stands up under the repeated shock torsion loads developed in these machines, and it costs less than forgings.

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cass without introducing a layer of bonding material. This produces a practically homogeneous structure very nearly duplicating the original.

With recent easing of government restrictions on the rubber content of tread material and with modern application techniques, the service life of retreaded tires should equal that of original equipment, Raney concluded.

European Cars Highlight Detroit Meeting

• Detroit Section
W. F. Sherman, Field Editor

Oct. 1—SRO signs were hung out by the Detroit Section when more than 1,000 people crowded the large auditorium at the Rackham Memorial Building for Detroit's opening meeting of the season. Speakers were **Maurice Olley**, director of research and development of Chevrolet, and **Troy Ruttman**, winner of the 1952 Indianapolis Race.

Highlight of the meeting was a display of 13 foreign automobiles on the plaza in front of the Rackham Building. The exhibit was considered the largest showing of foreign automobiles ever staged in Detroit. It covered the range from high-performance sports cars to conservative and economical light cars. The display opened at 4:00 p.m. and continued under floodlights until nearly 11:30 p.m.

Maurice Olley devoted his talk to the subject of "European Automotive Developments."

"The interest in European cars is not so much that they are smaller and lighter than ours, but that they are frequently made of different materials from ours, and put together in a different shape to meet entirely different conditions of use," Olley said. "Sooner or later, each country has to face the question of how much of the nation's resources one individual is justified in using for his own personal transportation, and how much road space he is entitled to occupy. . . . The fact that the European attempt (to be realistic) is not entirely successful in motorizing the European scene overnight is chiefly because European economic conditions are not advancing as fast as the demand for personal transportation and other luxuries. . . . In Africa . . . the conditions for the use of automobiles are similar to the American conditions of 40 years ago."

Conditions in many parts of the world are providing a market for somewhat specialized vehicles, Olley declared. Faced with considerable demand, European manufacturers nevertheless contend with restricted output due to lack of dollars or purchasing power on the part of some prospective customers, a general shortage of materials and the lack of aggressive competition in the supply of materials and finished parts. Cartels tend "to keep costs high, and also keep ideas low," the speaker observed.

"The American attitude toward anything foreign is one of good-natured contempt," Olley asserted. Then he proceeded to analyze a wealth of designs and ideas expressed in some current typical European automobiles in a thought-provoking way. Scores of photographic slides illustrated the talk. Vehicles discussed included the Citroen, the Dyna Panhard, the 750 Renault, the Hanomag three-seater, the Volkswagen, the Austin A40 and model 7, the Lancia Aurelia, the Hotchkiss Gregoire, the Alfa Romeo, the Fiat 1400, the Jaguar XK120 Sports Car, the Mercedes 300, the British Ford, the Hillman Minx, the Morris, the Opel, the Porsche, the Simca, the Gutbrod 2-cycle engine, the Allard, the British Lagonda.

Summarizing, Olley said, "All that has been attempted is to give a picture of a mentally vigorous industry which is finding certain desirable qualities in some of the things which the American industry has scarcely tried."

Ruttman, originally scheduled as coffee speaker at the banquet, was persuaded to address the entire assembly in the auditorium. In his discussion he gave a running account of his own thoughts and reactions in the Indianapolis 500 Mile Race and supplemented this with a narrative of the Mexican Road Race which he led at the half-way mark, and in which he finished fourth against a field that included some of the most noted European automobiles.

Rocket Uses Limited By High Fuel Consumption

• Cincinnati Section
Edward B. Lohaus, Field Editor

Oct. 27—The aircraft powerplant situation has never been as confused as it is today, said **Lt. Col. D. M. Ross** of the powerplant laboratory at Wright Air Development Center.

Originally the powerplant engineer had only one engine, the reciprocating engine, to worry about, Ross told the group. Now there are four other air-breathing powerplants — turboprop, turbojet, ramjet and pulsejet—and two non-air breathing powerplants—the rocket and nuclear propulsion.

The great advantage of jet engines is their reduced bulk, but the tremendous rise in fuel consumption is a considerable drawback, Colonel Ross said. A major limiting factor today

is the lack of materials capable of withstanding high temperatures.

Rocket and nuclear-propelled engines are the powerplants of the future, Ross asserted, because they are not dependent on the earth's atmosphere for "breath." They are the only powerplants that today promise speeds of 3000 mph and up. Discussion brought out, however, that the high fuel consumption of rockets limits their use to guided missiles, boosters, and so forth at present. They will probably not be used in any but experimental planes until fuel consumption can be reduced.

Nash-Healy Car Built in 3 Countries

• Dayton Section
T. L. Deger, Field Editor

Oct. 7—In speaking at Dayton Section's first meeting of the year, **Earl L. Monson**, chief development engineer of the Nash Motors Division of Nash-Kelvinator Corp., stated that the main items of interest to the automotive industry as concerns the Nash automobiles are Nash styling, the Nash Rambler, and the Nash-Healy sports car.

To satisfy the auto buyers' current desire for European and Continental body styling, Nash has selected the famous Italian automotive designer Pinin Ferrina to design the bodies on all Nash automobiles. This new trend in body styling is reflected in all their cars, and is responsible for a considerable increase in the demand for all types of Nash cars. Ferrina was selected on the basis of his success scored in International auto shows.

The Nash Rambler was introduced to broaden the sales possibility to a new group of consumers desiring a cheap dependable sports car, Monson asserted. The Rambler contains the Nash 600 engine and was tested for one year under actual driving conditions through all seasons of the year. On a run from Florida to California, gas consumption was checked at 31.7 miles per gallon. Original production on the Rambler was started in February, 1950 at a rate of 125 cars per day. The car was received by the motoring public with such enthusiasm that in order to meet the demand, the original plant was moved to Kenosha, Wis., where a current production rate of 275 cars per day is being maintained. Production has increased from 12,000 cars in 1950 to 60,000 cars in 1952, and it is expected that 100,000 Ramblers will be produced in 1953.

In relating the history of the Nash-Healy sports car, Monson pointed out that it is the motoring public themselves who dictate the trends of design and mechanics in the automotive industry. Individualists desiring to drive sports and custom cars of distinction have thus dictated the need for a new and different custom type sports car, a car with speed, sound mechanical design, and body styling with the continental look.

The engine of the Nash-Healy is built in the U.S., then shipped to England where it is placed in an English built chassis and then shipped to Italy where an Italian built body is assembled to complete the car. The completed car is then shipped to the U.S. for distribution and sale. Monson stated that the cost of the Nash-Healy, as presently built in inter-global stages, is less than it would be, were it completely built in the U.S. This is due to variation in labor wage scales between the U.S. and foreign countries.

Monson further stated that acceptance has far exceeded expectation and that present building schedules and facilities will be unable to satisfy the demand. Discussion following the talk brought out the following points of interest:

(1) Top speed of Nash-Healy, top off and windshield off, is 111 miles per hour.

(2) Acceleration of Nash-Healy, 0-60 miles per hour in 8 seconds.

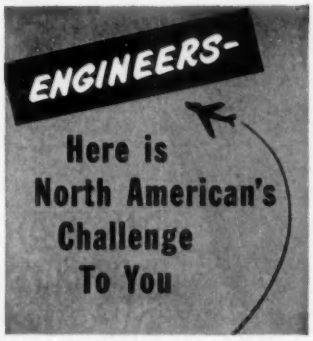
(3) Gas consumption of Nash-Healy is comparable to that of the Buick Dynaflow.

Monson was introduced by E. F. Riesing, special project engineer at Inland Manufacturing Division, General Motors Corp. A scroll of appreciation was presented to the outgoing Section Chairman C. I. Lathrem, by incoming Section Chairman S. E. Connair.

Closing Date

SAE Journal strives, in these pages, to bring to Society members live, prompt news coverage of every Section meeting. Material is provided by Section field editors.

With dates determined by printing schedules, this issue covers all Section meeting news received in New York up to November 12.



Frankly, working at North American requires hard thinking and plenty of vision. Because North American always works in the future. Yet, if you are interested in advanced thinking, if you'd like to work on the planes that will make tomorrow's aviation history, you'll like working at North American. North American offers these extra benefits, too.

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To help you over your peak engineering loads or to get going on the many long range projects that you have kept promising yourself to get under way. Many well-known companies in the automotive and related industries have found the use of our experienced engineering assistance expedient and economical, a short cut to production and quicker profits. Some of our present work is in engines • compressors • chassis • rear axles • automatic transmissions • off-the-road equipment • mobile equipment for weapons handling • aircraft power package • diesel scavenging tests and development • trucks • tractors. We have been told our charges are reasonable too. No more than your own engineering rates, sometimes less when you take your own departmental overhead into consideration. May we have the privilege of telling you more about what we can do for you.

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AUTOMOTIVE ENGINEERING • MECHANICAL ENGINEERING • Research • Development Testing • Prototypes

SAE Students Enter Industry

GEORGE S. WILLIAMS (McGill University '52) is now a technical trainee in production engineering at the Aero-Engine Division of Rolls-Royce, Ltd., in Derby, England. Williams' post-graduate training in Great Britain is being provided for by an Athlone Fellowship, awarded to him by McGill last spring.

WILLIAM H. PARK (Pennsylvania State College '52) is a mechanical design engineer for Sanders and Thomas Engineering Co., Pottstown, Pa.

EUGENE V. HUNTLEY (Ohio State University '52) has joined GMC's Packard Electric Division, Warren, Pa., as a process engineer.

RICHARD J. RUPP, JR. (Parks College '52) is a second lieutenant in pilot training with the U. S. Air Force.

MICHAEL J. KICZENSKI (Michigan State College '51) is with GMC's Ternstedt Division, Detroit, as a production supervisor.

DONALD E. KLEIN (University of Michigan '52) is an ensign in the U. S. Navy aboard the U. S. S. Sproston.

HOWARD FELDMAN (Parks College '52) is now a stress engineer for Hussman Aircraft Co., St. Louis, Mo.

ARNOLD A. ELSBERND (Parks College '52) has joined Cessna Aircraft Co., Wichita, Kans.

CHARLES E. DeROSE (University of Idaho '52) is an aeronautical research intern for the National Advisory Committee for Aeronautics at Moffett Field, Calif.

CHARLES R. KILGORE (Purdue University '52) is a research assistant at the department of engineering research of Pennsylvania State College, while doing graduate work at the College.

MATTHEW A. OPEKA (Carnegie Institute of Technology '52) is a junior engineer for Mesta Machine Co., Homestead, Pa.

GALEN F. RICHARDS (General Motors Institute '52) is with GMC's Inland Manufacturing Division, Dayton, Ohio, as a junior cost estimator.

WILLIS H. TAYLOR (New York University '52) is a mechanical designer for Farrand Optical Co., Inc., in New York City.

ERNEST R. McADOO (Tri-State College '51) is now a quality control engineer for Clark Brothers Co., Olean,

Unique production processes build Extra quality into

Eaton Valve Seat Inserts

Years of production experience and close engineering cooperation with leading engine manufacturers, combined with modern high-volume facilities, enable Eaton to furnish high-quality valve seat inserts to meet the specific requirements of the automobile, truck, and tractor industries. The range covers all types of inserts from low-priced, volume production passenger car inserts up to large-size, puddled-face inserts of suitable materials for large heavy-duty installations. A unique method of puddling special facing materials on insert seats enables Eaton to furnish inserts with superior corrosion and wear-resistant qualities at minimum cost.

You can utilize Eaton's long experience in this field by giving our engineers an opportunity to work with yours in the early stages of design.

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Free machinability
Dense, homogeneous structure
Freedom from leakage under pressure
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SAE Students Enter Industry

continued

N. Y. He was previously with GMC's A. C. Spark Plug Division.

JACK W. DUNBAR (Fenn College '52) has joined National Malleable and Steel Castings Co., Cleveland, Ohio, as a quality control supervisor.

HENRY E. KENISTON (North Carolina State College) received his master's degree last spring and is now a mechanical engineer at the Beacon Laboratories, Beacon, N. Y., of the Texas Co.

ROBERT L. LACEY (Purdue University '52) is in training with the Mead Corp., Chillicothe, Ohio.

JAMES K. KNAELL (Ohio State University '52, is with the U. S. Steel Co., Clairton, Pa., as an engineer in training.

JOHN P. LAURI (College of the City of New York '52) is a tool engineer for Grumman Aircraft Engineering Corp., Bethpage, N. Y.

AIME BARIBEAU (McGill University '52) has joined the Canadian International Paper Co., Three Rivers, Que., as a mechanical engineer.

NEIL H. PERKINS (Parks College '52) is a second lieutenant in the U. S. Air Force stationed at Wright-Patterson Air Force Base, Dayton, Ohio.

RICHARD C. MEYER (University of Wisconsin '52) has joined the vibrations department of Hamilton Standard Division of United Aircraft Corp., Windsor Locks, Conn.

KENNETH SOUTHALL (University of Connecticut '52) is a designer engineer for E. I. duPont de Nemours and Co., Wilmington, Del.

IVO M. AMARAL (Cal-Aero Technical Institute '51) is with Wilberding Co., Inc., Washington, D. C., while doing graduate work at George Washington University.

THOMAS A. RACINE (Purdue University '52) is a product tester in the industrial power engineering department of International Harvester Co., Melrose Park, Ill.

ALEX GONZALEZ (Academy of Aeronautics '52) is an aerodynamicist for North American Aviation, Inc., Los Angeles, Calif.

C. RODNEY DAVIS (University of Massachusetts '52) is a test engineer for General Electric Co. in Lynn, Mass.

ROBERT C. HOLAN (University of Michigan '52) is a junior graphic engi-

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Technical Service Data Sheet
Subject: PROTECTING FRICTION SURFACES WITH THERMOIL GRANODINE®

INTRODUCTION

Fabricators and product designers, particularly in the automotive field, are aware that even highly polished surfaces under friction weld, gall and score. One of the most inexpensive and practical methods of preventing this is to coat the metal to prevent metal-to-metal contact. With cast iron or steel, the "Thermoil-Granodine" manganese-iron phosphate coating provides a wear-resistant layer of unusual effectiveness.

Thermoil-Granodizing greatly prolongs the life of parts subject to friction. It protects the surface of products like the diesel engine liners shown above and the many moving parts of automobiles and other machines. "Thermoil-Granodine" with its remarkable lubricating properties is particularly valuable in these and similar applications because of its ability to retain oil and maintain lubrication under high pressures and high velocities. This ACP wear-proofing chemical not only permits rapid break-in without scoring, scuffing and welding but also reduces subsequent wear on friction parts.

"THERMOIL-GRANODINE" PROTECTS RUBBING PARTS

Thermoil-Granodizing removes "fuzz" from ferrous metal friction surfaces and produces a coating of non-metallic, water-insoluble manganese-iron phosphate crystals which soak up and hold oil as bare untreated metal cannot do. The oiled crystalline "Thermoil-Granodine" coating on piston rings, pistons, cylinders, cylinder liners, cranks, cam-shafts, gears, tappets, valves, spiders and other rubbing parts, allows safe break-in operation, eliminates metal-to-metal contact, maintains lubrication and reduces the danger of scuffing, scoring, welding, galling and tearing of the metal. The work to be protectively treated is merely Thermoil-Granodized and oiled, usually with a soluble oil.

"THERMOIL-GRANODINE" MEETS THESE SPECIFICATIONS

SPECIFICATION NUMBER	SPECIFICATION TITLE
MIL-C-16232 Type I	Coatings — phosphate; oiled, slushed, or waxed (for ferrous metal surfaces) and phosphate treating compounds.
AN-F-20 (See also U.S.A. 3-213)	Finishes, for electronic equipment.
U.S.A. 57-0-2C Type II, Class A	Finishes, protective, for iron and steel parts.
U.S.A. 51-70-1 Finish 22.02, Class A	Painting and finishing of fire control instruments; general specification for
M-364	Navy aeronautical process specification for compound phosphate rust-proofing process.

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WRITE FOR FURTHER INFORMATION ON "THERMOIL-GRANODINE" AND ON YOUR OWN METAL PROTECTION PROBLEMS.

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Leading excavator manufacturers offer Twin Disc Drives as standard equipment . . . because the digging business puts shovels, draglines, loaders to the severest tests met by any industrial machinery.

So, where the going is toughest . . . wherever work output depends on husky drives . . . you find the brawn of engine and machine linked by Twin Disc friction and hydraulic drives for top performance.

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Twin Disc Drives are offered as standard on Lima Shovels. A Twin Disc Power Take-Off is the main engine Clutch, and two Model 8 Clutches (one shown) control the swing on the Lima Type 34 Paymaster Shovel.

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SAE Students Enter Industry

continued

neer with Pontiac Motor Division of General Motors Corp., Pontiac, Mich.

HAROLD W. FODDY, JR. (University of Colorado '50) has been released from active duty with the U. S. Air Force and is now with the Gas Service Co., Wichita, Kans.

PAUL L. DRUSYS (Academy of Aeronautics '52) is now in the U. S. Army at Aberdeen Proving Ground, Aberdeen, Md.

ROBERT E. COHEN (Michigan College of Mining and Technology '51) is an ensign in the U. S. Navy. Ensign Cohen is transportation officer of the U.S.S. Salem.

ROBERT V. YAZEJIAN (University of Detroit '52) has joined Metro Tool and Die Co., Detroit, as a mechanical engineer.

ALBERT T. REIFF, JR. (Cornell University '50) received his master's degree in automotive engineering from Chrysler Institute in June and is now a research engineer in the special engine research department of the Beacon Laboratories of the Texas Co., Beacon, N. Y.

ROBERT J. COOPER (West Coast University '51) is a test and sales engineer for Furane Plastics, Inc., Glendale, Calif.

JAMES C. HOELLE (Indiana Technical College '51) has joined Hyskind Heating and Plumbing Co., Fort Wayne, Ind.

ROBERT A. FAY (California State Polytechnic College '52) is a research analyst for Northrop Aircraft, Inc., Hawthorne, Calif.

NORMAN D. ESAU (Purdue University '52) is an automotive engineer at the Whiting, Ind., laboratory of Standard Oil Co. (Ind.)

EDWARD F. DONAHUE (Franklin Technical Institute '52) is a laboratory assistant in the Sloan Automotive Laboratory at Massachusetts Institute of Technology, Cambridge, Mass.

SAMUEL B. CRIPE (Purdue University '50) has returned from 16 months of active duty with the Navy and is plant engineer for Mid-States Steel and Wire Co., Crawfordsville, Ind.

HAROLD P. HORWITZ (Indiana Technical College '52) is a design and development engineer for Radio Corporation of America, Camden, N. J.

RALPH H. JOHNSON (University of Washington '52) has joined GMC's

SAE Students Enter Industry

continued

Cadillac Motor Car Division, Detroit, as laboratory technician.

JOSEPH W. HELME (Stevens Institute of Technology '52) is an assistant in the Powder Metallurgy Laboratory of Stevens Institute, Hoboken, N. J., while continuing his studies as a graduate student at Stevens.

LEO F. SANDER (Parks College '52) is now with the maintenance department of United Air Lines, South San Francisco, Calif.

WARREN M. WIESE (University of Minnesota '52) is in training with the Research Laboratories Division of GMC, Detroit.

JAMES R. HUNTER (Purdue University '52) has joined General Motors Corp.'s Delco-Remy Division, Anderson, Ind.

LeROY F. MEREDITH, JR. (Stevens Institute of Technology '52) is now in training with the chemical department of the experimental station of E. I. duPont de Nemours and Co., Wilmington, Del.

HERBERT H. LEE (University of Michigan '52) has joined Piasecki Helicopter Corp., Morton, Pa.

RICHARD E. WAINERDI (University of Oklahoma '52) is a junior exploitation engineer for Shell Oil Co., Houston, Texas.

JOSEPH W. ACKER (Cornell University '52) is with the Lincoln Electric Co., Euclid, Ohio, as a project engineer.

WILMER W. WAGNER (University of Oklahoma '52) is in training with Phillips Petroleum Co. at Phillips, Texas.

HOMER O. WILKENS, JR. (Clemson A and M College '52) is with Boeing Airplane Co., Seattle, Wash., as a junior engineer.

ROBERT SALEM (Northrop Aeronautical Institute '51) is a flight test analyst for Northrop Aircraft, Inc., Hawthorne, Calif.

DENIS SAVIGNAC (Ecole Polytechnique '52) has joined Marine Industries, Ltd., in Sorel, Que.

HOWARD W. HINES (Parks College '52) is a junior engineer for Cessna Aircraft Co., Wichita, Kans.

DONALD L. STEPHENS (University of Washington '51) has joined Pacific Car and Foundry Co., Renton, Wash.

HOWARD D. SPRINGER (University

Photos Courtesy The Massey-Harris Company.

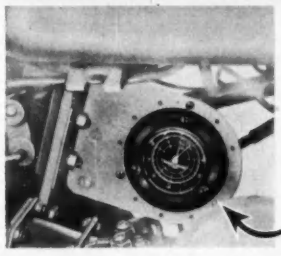
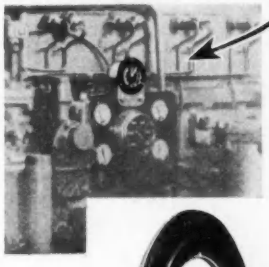


Photo Below Courtesy Cummins Engine Company, Inc.



The Sure Way to "Design out" Vibration and Shock Damage.

Lord Meter Mountings are paying dividends to manufacturers and users of heavy duty industrial and farm tractors, lift trucks, stationary engines and many other industrial machines where shock and vibration are encountered.

The Lord Meter Mount assures the accurate performance designed into Hobbs Engine-Hour Meters when they are subjected to excessive vibration on farm tractors and stationary diesel engines. These meters are protected from the damaging effects of vibration and shock by the unique method of combining shear and rolling action of the rubber to absorb destructive forces. The outer ring is mounted to the panel and the inner ring holds the meter thus giving protection in multi-planes. The rubber between these rings does the work. We will be pleased to have the opportunity to help you in the application of Lord Meter Mountings.

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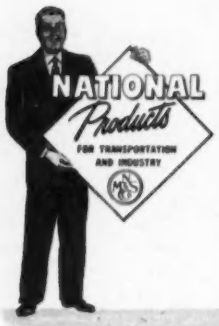

Products bearing these familiar trademarks have all established enviable reputations for quality and dependability.

These manufacturers *continue* to procure castings by National—one of the Nation's largest founders.

National's unparalleled experience in producing malleable, heat-treated malleable, and steel castings is at your disposal. Sales offices and engineering facilities are located at all five strategically located plants. A-5345

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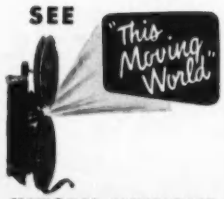

A 16mm technicolor film. Narrated by Edwin C. Hill, this 27-minute film tells how malleable iron is made . . . tested . . . used . . . how its production economy, ductility, machinability, toughness will give you a better finished product. Available for group showings.

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FOR TRANSPORTATION AND INDUSTRY

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY
CLEVELAND 6, OHIO
Est. 1868

SAE Students Enter Industry

continued

of Michigan '52) is now a naval architect with Carl J. Nordstrom, Seattle, Wash.

WILLIAM C. KEIL (University of California '52) is an engineer for United Airlines in South San Francisco, Calif.

ROBERT W. LAWRENCE (University of Pittsburgh '52) has joined Pratt and Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn., as a junior test engineer.

ODEN F. JESTER, JR. (University of Iowa '52) is in training with Electro-Motive Division of GMC, LaGrange, Ill.

OMAR HANSEN (Purdue University '52) is a junior engineer for Curt G. Joa, Inc., Sheboygan Falls, Wis.

RICHARD D. MOAN (University of Detroit '52) is now with GMC's Detroit Transmission Division, Plymouth, Mich., as a junior engineer.

RICHARD G. HALL (Michigan College of Mining and Technology '52) is a mechanical engineer for the Navy's Bureau of Ships, Washington, D. C.

EDWARD W. GLATFELTER (Pennsylvania State College '52) is a junior design engineer for A. B. Farquhar Co., a division of Oliver Corp., in York, Pa.

JAMES J. GILCHRIST (Parks College '52) is a field service engineer for the aviation gas turbine division of Westinghouse Electric Co., Essington, Pa.

ROBERT W. MALONE (University of Detroit '52) has joined Shell Oil Co. in Martinez, Calif.

RAYMOND J. SYMONS (University of Michigan '52) is with Pontiac Motor Division of GMC, Pontiac, Mich., as a road test engineer.

STANLEY B. MURPHY (California Polytechnic College '52) is in training with Westinghouse Electric Corp., Pittsburgh, Pa.

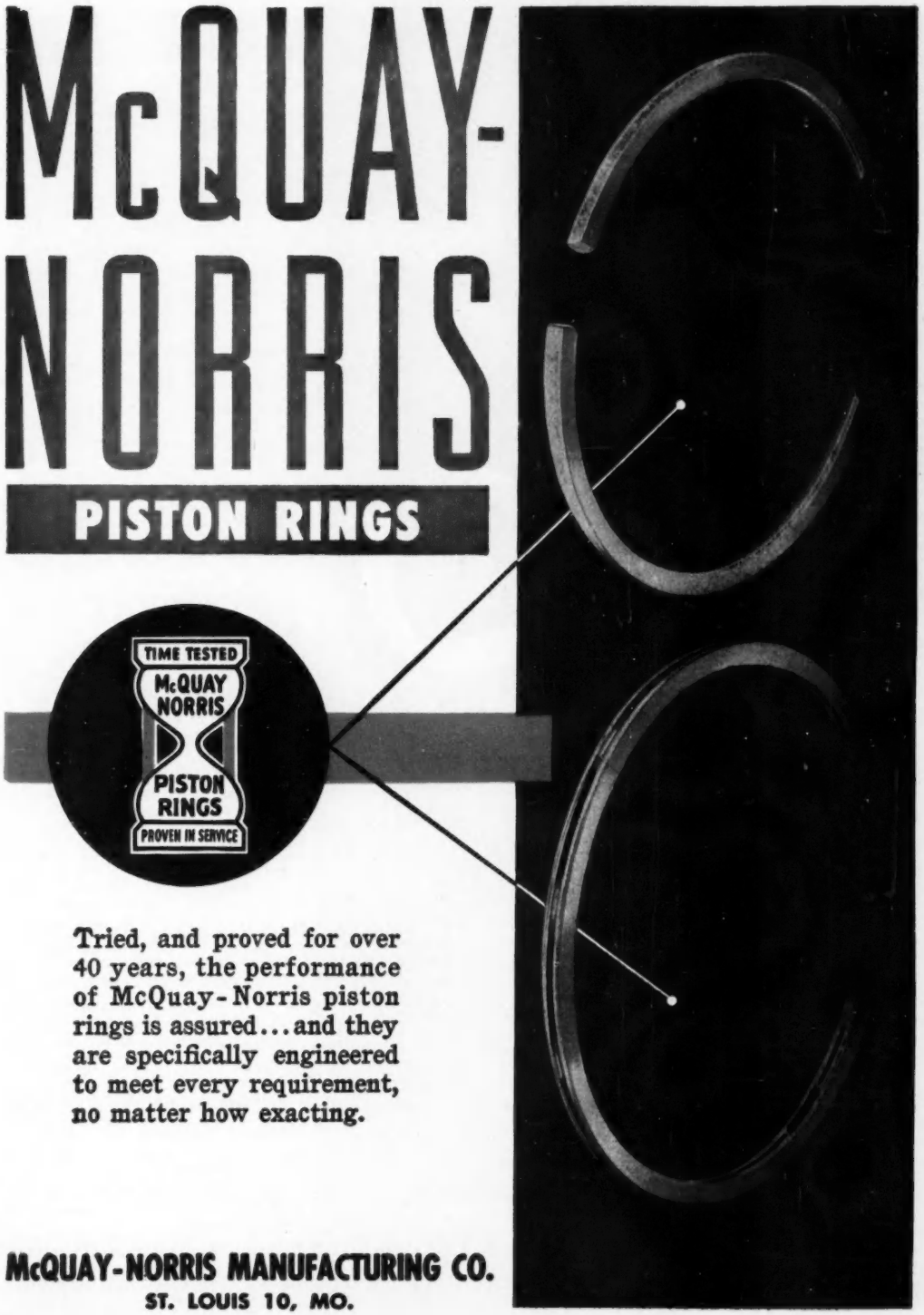
RICHARD S. FAIRALL (California Institute of Technology '50) received his master's degree from Cal Tech in 1951 and is now a preliminary design engineer for AiResearch Mfg. Co., Los Angeles.

CHARLES G. FLETCHER (Massachusetts Institute of Technology '52) has joined Smith, Hinchman and Grylls, Inc., Gorham, N. H., as a mechanical engineer.

NICHOLAS J. CONSTANTINE (University of Cincinnati '52) is a technical engineer for the aviation gas turbine

McQUAY-NORRIS

PISTON RINGS



Tried, and proved for over 40 years, the performance of McQuay-Norris piston rings is assured... and they are specifically engineered to meet every requirement, no matter how exacting.

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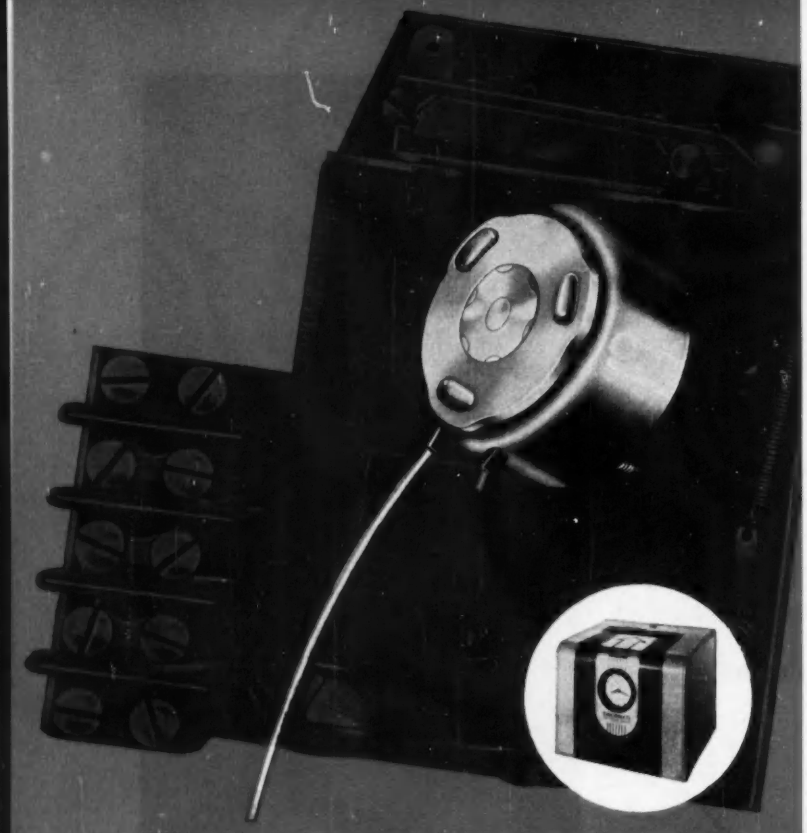
ST. LOUIS 10, MO.



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The compact, powerful number five Ledex Rotary Solenoid is used to replace the bulky old type solenoid in the Cincinnati series 800, Automatic Time Recorder. By comparison Ledex Rotary Solenoids have 1/7 the weight . . . produce twice the power output with the same electrical input . . . proved to be more dependable and easier to install . . . and reduced the cost of this component 70%. The actual size illustration of the solenoids show the advantage of Ledex compactness . . . 1/6 the volume.

Let Ledex Engineers assist you in choosing rotary solenoids that will save production costs and help increase the efficiency of your products. Six basic models range in diameters from 1¼" to 3⅝", with torque values from ¼ to 50 pound-inches. Various power linkages and types of mountings are available. Write today for descriptive literature.

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SAE Students Enter Industry

continued

division of General Electric Co., Evendale, Ohio.

LESLIE R. COX, JR. (Purdue University '52) is a junior test engineer for Wright Aeronautical Division of Curtiss-Wright Corp., Wood-Ridge, N. J.

ALPHONS A. BOGEN (Northwestern University '51) is with Minneapolis-Honeywell Regulator Co., Chicago, Ill., as a designer.

ERIC C. NULSEN (Cornell University '52) is in training with the Whirlpool Corp., St. Joseph, Mich.

IRVING M. BANT (Northrop Aeronautical Institute '51) is an engineering draftsman with Yoh Engineering, Inc., Los Angeles, Calif.

CARL L. NIGH (General Motors Institute '52) is in training in the bearing engineering department of GMC's Allison Division, Speedway, Ind.

ROBERT L. CARLSON (Illinois Institute of Technology '52) has joined International Harvester's Melrose Park Works, Melrose Park, Ill., as a machine designer.

KELVIN C. BROWN (University of Saskatchewan '52) is in training with A. V. Roe Canada, Ltd., Malton, Ont.

J. DONALD CLEAVINGER (California State Polytechnic College '52) is a trainee for Goodyear Tire and Rubber Co., Akron, Ohio.

WILLIAM J. WOOD (University of California '52) is with Butler Mfg. Co., Richmond, Calif.

GEORGE GAYDOS (Detroit Institute of Technology '52) is a junior engineer with Lockheed Aircraft Corp., Burbank, Calif.

DON H. WACKER (Michigan College of Mining and Technology '52) has joined the Research Laboratories of General Motors Corp., Detroit.

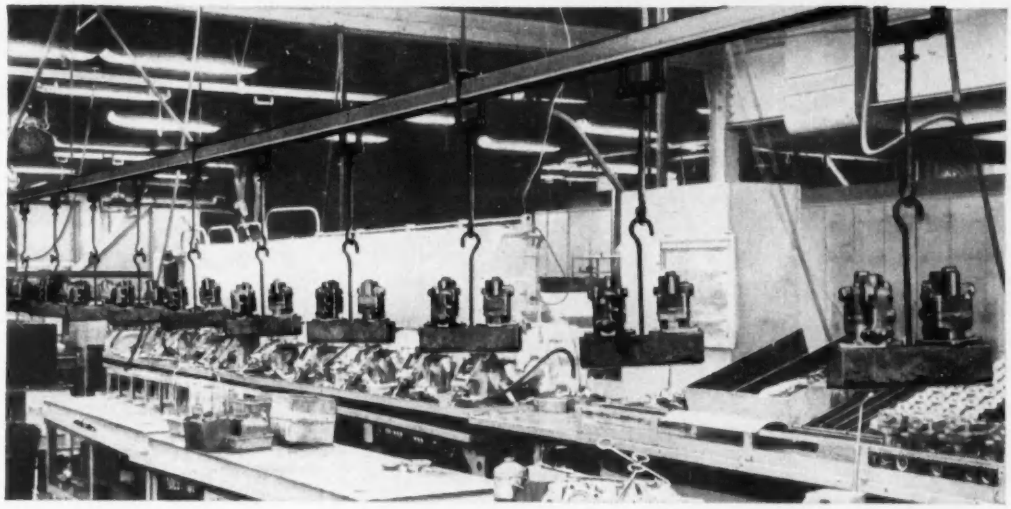
JAMES J. TESIK (Manhattan College '52) is an assistant product engineer for Sperry Gyroscope Co., a division of Sperry Corp., Great Neck, N. Y.

CHARLES G. SLATER (Pennsylvania State College '52) has joined the Clark Brothers Co., Olean, N. Y.

ALGER R. JOHNSON (Southern Methodist University '52) is an engineering trainee for Detroit Diesel Engine Division of General Motors Corp., Detroit.

DINO L. FONTANA (Detroit Institute of Technology '52) is with Lockheed Aircraft Corp., Burbank, Calif., as a junior engineer.

MASS PRODUCTION METHODS



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VICKERS PUMPS for Hydraulic Power Steering

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These pumps incorporate Vickers design principles that have been proven in the most difficult industrial service over the last 25 years. Another reason for their superiority is the manufacturing "know how" Vickers has acquired during that time. As a result, these pumps can be depended upon to deliver ample hydraulic power for steering over a very wide range of operating speeds, temperatures and pressures.

Vickers Pump with integral volume control and relief valves and oil reservoir.

Vickers Pump with integral volume control and relief valves.

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CITY _____ ZONE _____ STATE _____ 1706

New Members Qualified

These applicants qualified for admission to the Society between Oct. 10, 1952 and Nov. 10, 1952. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

George Dwelle Elyea (A), Daniel J. Tolan (J).

British Columbia Section

Frank J. Berto (J).

Buffalo Section

Herbert G. White (J).

Canadian Section

Richard Austin Evans (M), F. Gordon Murphy (M), John Edis Rymes (M), Alexander James Szabo (J), Patrick Gerald Tobin (A).

Central Illinois Section

Herbert L. Harrer (M), J. Philip Hensley (J), Richard Wright Kizer (M), K. Ward Lamport (J), Robert E. Stong (J), James H. Taylor (J).

Chicago Section

Charles Frederick Bohmert (M), Lawrence E. Donahue (M), B. L. Fisher (M), Sydney B. Jones (A), John Frank Kopczyk (J), William C. Mellender (M), Robert F. Nolan (M), Richard B. Press (A), M. Bradley Stevenson (A), Rudy A. Walter (A), Charles W. Wulff (A).

Cincinnati Section

Michael Field (M), Harry A. Truscott (M).

Cleveland Section

C. L. Burton (M), Roy E. Hamel (M), James Robert Jeromson, Jr. (A), J. Fred Krueck (M), James Haswell Lansing (M), Paul A. Likly (A), John E. McKeighan (A), D. H. Ruhnke (M), Charles H. Shelton (M), Robert C. Tupa (J).

Dayton Section

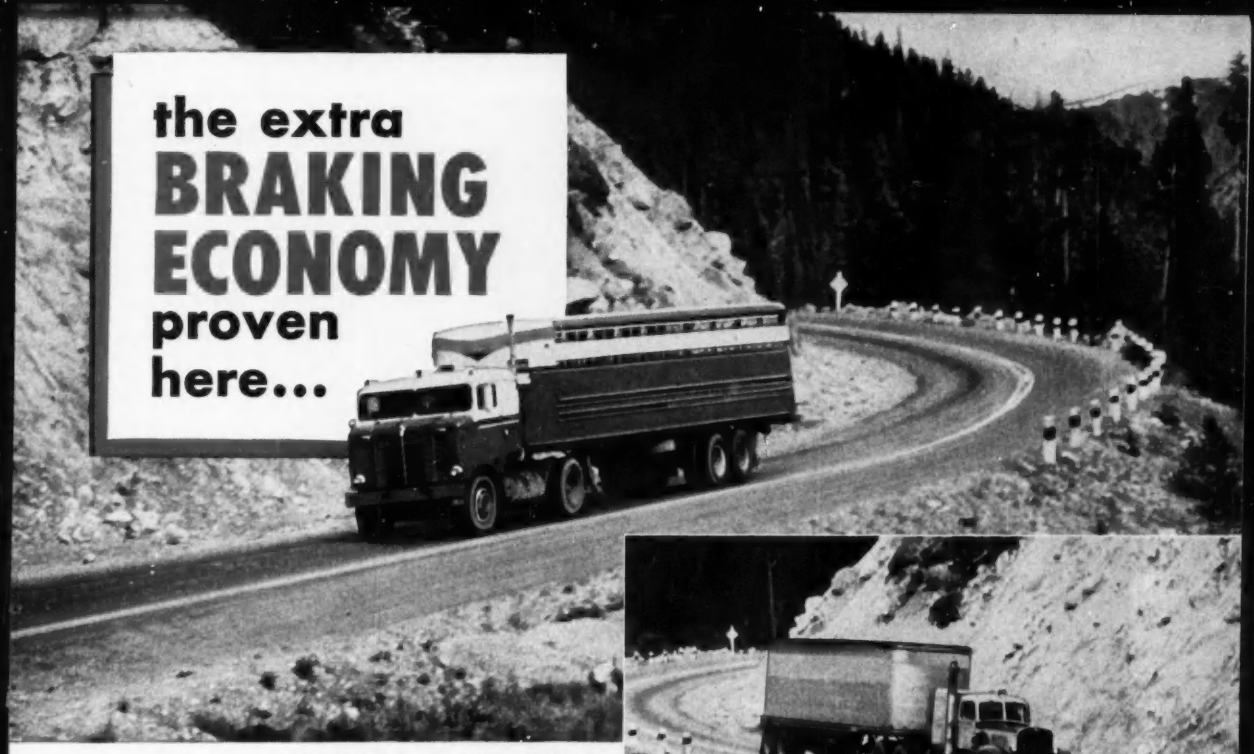
Jack W. Dern (J).

Detroit Section

Harold V. Atnip (M), Donald W. Bain (J), John D. Bartholomew (A), William A. Belfry (M), David Borodawkin (J), Herbert E. Clark (M), Stanley Carl Clemence (M), Gerald Wood Colby (J), James J. Dawson (J), John M. Hastings (J), Stanley L. Janky (M), William A.

Continued on Page 140

the extra BRAKING ECONOMY proven here...



High in the Rockies Crossing the Continental Divide.

...means MORE PROFITS on any hauling job

Cost Cutting Bendix-Westinghouse Air Brakes Reduce Downtime and Repairs on Rugged Mountain Runs!

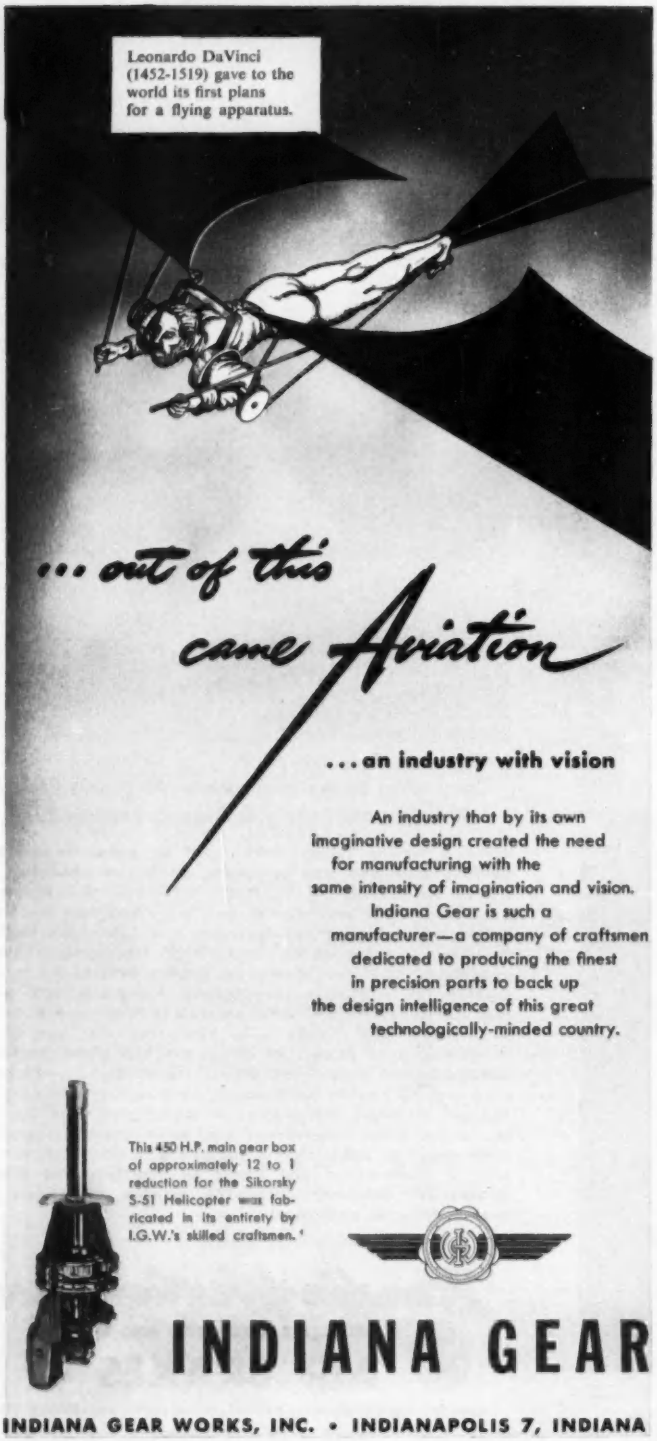
When a braking system proves itself for **safe, dependable performance and low operating costs** day after day over one of the toughest trucking routes in the country its got to be good! And that's exactly what Bendix-Westinghouse Air Brakes do on hundreds of trucks operating over Colorado's Berthoud Pass which cuts through the rugged Rocky Mountains at altitudes exceeding 11,000 feet. Here these **mighty brakes** are put to a grueling test—mile after mile of steep downgrades and sharp, tight curves that require almost constant braking application. Yet here, actual fleet records testify year after year that Bendix-Westinghouse Air Brakes pay off not only with **peak performance, positive control and utmost reliability,** but with actual hard cash savings on maintenance, parts replacement costs and reduced downtime. That's why, no matter what type trucks or busses you build and whether they're designed for operation across town or cross country, you can give your customers the most in performance and profits by specifying the **brakes proven for economy**—Bendix-Westinghouse, the world's most tried and trusted air brakes!

Bendix-Westinghouse

THE WORLD'S MOST TRIED AND TRUSTED

AIR BRAKES

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • ELYRIA, OHIO • BERKELEY, CALIF.


Leonardo DaVinci (1452-1519) gave to the world its first plans for a flying apparatus.
... out of this came Aviation
... an industry with vision
An industry that by its own imaginative design created the need for manufacturing with the same intensity of imagination and vision. Indiana Gear is such a manufacturer—a company of craftsmen dedicated to producing the finest in precision parts to back up the design intelligence of this great technologically-minded country.
This 450 H.P. main gear box of approximately 12 to 1 reduction for the Sikorsky S-51 Helicopter was fabricated in its entirety by I.G.W.'s skilled craftsmen.
INDIANA GEAR
INDIANA GEAR WORKS, INC. • INDIANAPOLIS 7, INDIANA

New Members Qualified

continued

Kuhn, Jr. (M), Kenneth L. Long (A), James C. McDonald (M), Herbert H. Mitson, Jr. (J), George J. Newman (A), Robert E. Owen (M), Curtis P. Parsons (J), Henry Plonski (A), George W. Schulz (J), John J. Searles (J), Louis Sibal (J), Leonard W. Thorpe (J), Edmund Trahey (J), Emory Newton Yount (J), Earl Ziegler (M).

Indiana Section

Henry O. Becker (J), Fred P. Duesenberg (M), Ralph Edgar Schumann (J).

Kansas City Section

George Michael Francis Carter (A), Glenn H. McMillan (A), William F. Purcell (J), Arthur C. Searle (A), Harold F. Wiseman (A).

Metropolitan Section

Donald M. Brown (M), Manning Harder Dandridge (J), William D. Jameson (M), Robert Gardner King (M), Maurice B. Miller (M), Robert George Reeves (J), Stephen V. Smith (J), Seymour Steiner (A).

Mid-Continent Section

Cray L. Foley (J).

Mid-Michigan Section

George Charles Wilson (J).

Milwaukee Section

Charles C. Devine (A).

Montreal Section

Timoleon Argyropoulos (J), Walter Barber (M), Robert B. Keefler (J), James N. Robinson (J).

New England Section

Charles Woodbury Bell (A), Vincent Carroccia, Jr. (A), Raymond C. Kelley, Jr. (A).

Northern California Section

Robert Henri Fischer (M), Cassius Elston Sewell (M), Harold E. Wheatley (A).

Northwest Section

Glenn H. Lewis (J).

Oregon Section

Dick Henry Gripp (A).

Continued on Page 142

Six strong arms and "true"

Six powerful arms of steel grip and turn the crankshaft—send power from pulsing pistons surging through the mighty Ford truck. These connecting rods are machined to tolerances of 3/10,000 of an inch—diamond-bored for precision—dynamically balanced to 1/10th of an ounce for peak performance. That's precision production—and for such exacting work in great volume, Ford Motor Company depends on Lycoming.

Lycoming stands ready to assist you—whether you have "just an idea" that needs developing, a problem in the blueprint stage, or a finished metal product that needs speedy fabrication. Long famous in the metal-working field, Lycoming continues to meet the most exacting and diverse requirements, both industrial and military. *Whatever* your problem—look to Lycoming!

Lycoming's 2½ million feet of floor space, its more than 6,000 machine tools, and its wealth of creative engineering ability stand ready to serve your needs.

AIR-COOLED ENGINES FOR AIRCRAFT AND INDUSTRIAL USES • PRECISION-AND-VOLUME MACHINE PARTS • GRAY-IRON CASTINGS • STEEL-PLATE FABRICATION

LOOK TO LYCOMING FOR RESEARCH FOR PRECISION PRODUCTION

LYCOMING-SPENCER DIVISION, WILLIAMSPORT, PA.
BRIDGEPORT-LYCOMING DIVISION, STRATFORD, CONN.

AVCO MANUFACTURING CORPORATION

For precision "arms" —connecting rods that perfectly pass power along to a truck's wheels— Ford Motor Company depends on Lycoming precision production.

Lycoming-Spencer Division
AVCO Manufacturing Corp.
652 Oliver Street
Williamsport, Pa.

Please send me further information on Lycoming's varied abilities and facilities.

Name_____

Firm_____ Title_____

Address_____

City_____ Zone____ State____

New Members Qualified

continued

Philadelphia Section

Forrest Benton Arnold (A), Jerome P. Berliner (J), Charles V. Toner (J), William R. West (J).

St. Louis Section

George Wilbur Brown (M), August H. Leu (M).

San Diego Section

Nicholas Marechal (J).

Southern California Section

Robert E. Barnes (M), John E. Crawford, Jr. (J), Robert V. Evleth (J), C. Phil Frame (J), James Joseph Gartland, Jr. (A), William C. Heath (J), J. Milton Jenkins (A), Edward E. Merritt (M), Carl O. West (SM).

Southern New England Section

Fred John Gross, Jr. (J).

Texas Section

Robert E. Dudley (A), Franklin Arthur Landers (M), George Robert Perryman (A), William Buck Schell (M).

Washington Section

David L. McBride (M), Lt. Col. Alfred S. Williamson (SM).

Outside of Section Territory

Kenneth W. Parsons (M), Kenneth G. Perry (J), George Milton Savage (J), Edward M. Smith (J).

Foreign

Martin Bernard Hamilton DeSilva (FM), Ceylon; Ferdinand E. E. Dierkens (FM), Belgium; Capt. Taj Jilani (FM), Pakistan.

S-A-F-E-T-Y
HERE-
Warns approaching cars.
and
HERE-
Warns cars following.
and
HERE-
Reassures the driver.
TUNG-SOL
FLASHER
P229D
PAT. NO. 1979349
MADE IN U.S.A.
Only the Tung-Sol Signal Flasher provides this three-way warning for automotive uses—ahead—behind—and on the instrument panel. The important instrument panel pilot light tells the driver his signals are operating, or, by not flashing, warns him of a circuit failure.
More than 13,000,000 Tung-Sol Signal Flashers have been used and they usually outlast the cars they're on.
TUNG-SOL ELECTRIC INC., Newark 4, N. J.
Sales Offices: Atlanta • Chicago • Culver City • Dallas Denver • Detroit • Newark • Philadelphia
Tung-Sol Makes:
All-Glass Sealed Beam Lamps, Miniature Lamps, Signal Flashers, Picture Tubes, Radio, TV and Special Purpose Electron Tubes.
TUNG-SOL®
SIGNAL FLASHERS
Make warning lights more commanding

Applications Received

The applications for membership received between Oct. 10, 1952 and Nov. 10, 1952 are listed below.

Atlanta Group

John Francis Collins.

Baltimore Section

George Andrew Bamford, Arne P Rasmussen, Gordon A. Sossich.

British Columbia Section

Earl Stanley Bengston, David Edward Broster, Ivan John Carr, John Alfred Herwynen, Clifford E. Leon, William Richard Morgans, Veli Rantala, Kenneth Howard Wilson.

Buffalo Section

Frank M. Baumgardner.

Canadian Section

Donald A. MacLean, Alexander Murdock Marshall, Ernest Sidney Moore, Robert J. Twaddle, J. B. Webster, Donald Winans.

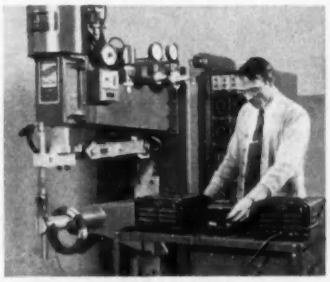
Central Illinois Section

Thomas W. Head.

Chicago Section

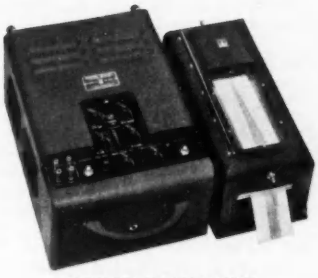
John T. Arima, Charles Blair Banks, M. D. Burrows, Daniel E. Christ, Don L. Clithero, James H. Graas, Donald J. Huegerich, Wallace S. Johnson, George W. Morris, Charles Eugene Overton,

Continued on Page 144



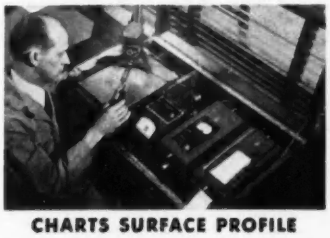
NEW WELDING ANALYZER

This new Brush Welding Analyzer helps you meet specifications without trial and error, and saves trouble-shooting time on three-phase resistance welders, single-phase resistance spot, projection, and seam welding machines. Chart records show magnitude and timing of variables, and give written proof of calibration and consistency of operation of equipment.



RECORDS STRAINS

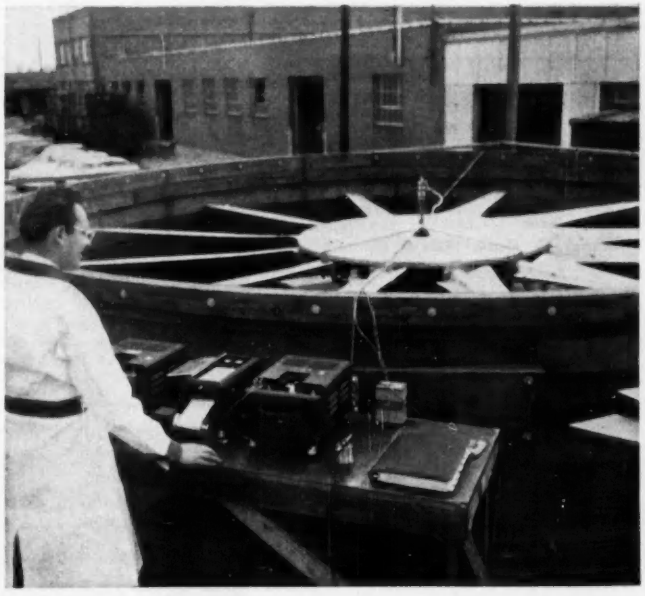
Brush Strain Analyzer, consisting of Amplifier and Magnetic Direct Inking Oscillograph, is a complete, portable unit for measurement of strains. The equipment records either static or dynamic strains up to 100 cycles per second with direction and magnitude shown on the chart.



CHARTS SURFACE PROFILE

The Brush Surface Analyzer® shows average roughness in micro-inches, and also provides a chart of surface irregularities. The chart shows a highly magnified profile of the surface, on which variations of less than 1 micro-inch are readily apparent. Eliminates guesswork in specifying and checking finishes.

For complete information write The Brush Development Company, Department N-44, 3405 Perkins Avenue, Cleveland 14, Ohio.



Streamlines measurement of operating stress with BRUSH RECORDING ANALYZER

● Here's another case where Brush Recording Analyzers simplify product development, by providing written records of operating data.

By mounting strain gages on the 20-foot cooling tower fan, and amplifying and recording the signals with a Brush Recording Analyzer, engineers of The Marley Company accurately observe operating stress on the fan, and can make quick adjustments of equipment for changing conditions.

This equipment provides a highly practical method of testing new design ideas, since measurements are recorded quickly and easily. The Marley Company, large producer of water cooling towers, also uses Brush Analyzers to check gear reducers, drive shafts, and structural members under actual service conditions.

Investigate Brush Recording Analyzers to streamline *your* testing of stress, strain, torque, vibration, pressure, and electrical characteristics. The direct-writing oscillographs provide a permanent chart record of the test—*immediately!* Brush representatives are located throughout the U.S. In Canada: A. C. Wickman, Limited, Toronto.

For catalog write The Brush Development Company, Dept. N-44, 3405 Perkins Avenue, Cleveland 14, Ohio.

PUT IT IN WRITING WITH A BRUSH RECORDING ANALYZER

THE Brush DEVELOPMENT COMPANY

BRUSH

Piezoelectric Crystals and Ceramics
Magnetic Recording Equipment
Acoustic Devices
Ultrasonics
Industrial & Research Instruments

Applications Received

continued

Earl B. Pridmore, Jr., Loyd Pylat.

Cincinnati Section

Samuel A. Dean, Marvin Wernersbach.

Cleveland Section

Harold R. Bangs, Robert D. High, Jordan Phillip Jung, William Manson Leavens, Michael Minich, Jr., Ralph E. Mottin, John Newell, III, Karl A. Roesch, Victor Rovtar.

Dayton Section

Anton F. Erickson, William A. Frye.

Detroit Section

David J. Alexander, Donald J. Armstrong, Marvin John Arnold, John G. Bannister, Robert Baxter, Francis L. Bedard, Donald Charles Bosker, William Lloyd Brown, Jackson G. Byers, Michael Brown, William L. Cameron, Robert F. Carlson, Julius A. Chelenyak, Nick Charles Colovas, John A. Cummings, Carle F. Cziske, E. M. Gage, George M. Galster, Lester C. Gates, Robert T. Gill, George T. Gorman, R. Fenton Hamilton, Carl M. Heath, H. R. Holmes, Jr., Andrew D. Hopkins, Robert G. Horchler, Kenneth Clifford Huhta, Michael Johnson, Jr., Rudolph J. Jonczy, Bobby Jack Ludwig, Ralph S. Mackey, Gordon William McIntosh, Malcolm R. McKinnon, John Mihasci, Jr., Edwin L. Miller, Harry Iddings Miller, Jr., Donald H. Mills, Steve J. Nagy, Oscar B. Noren, Charles H. Romans, Frank Chester Querry, Jr., John J. Schickel, Walter L. Schlaefflin, Robert Edward Tyner, Gaylord E. Underwood.

Hawaii Section

W. W. Miller.

Indiana Section

Walter J. Behrens, William L. Hudson, Paul Robert Lepisto, William James Nanfeldt.

Kansas City Section

Irving Marion McLeod, Jr., Marvin D. Vawter, James L. Wheeler.

Metropolitan Section

Robert N. Bateman, Charles J. Bitzer, Donald Davidson, George E. Fink, Franklyn H. Green, Glenn Ray Hershey, John Christopher Huebner, Philip L. Muller, Jr., Charles A. Roller, Norman S. Smith, Anthony Testa, Carll P. Van Gilder, David L. Staiger, James R. Summer, Ben Wanderman.

Mid-Michigan Section

Sanford Brown, Howard F. McColly, Anthony Waydak, Guy W. Wesson.

Milwaukee Section

Howard E. Galineau, Richard J. Heil, Walter A. Laev, Sr., Kenneth A. McLyman.

Montreal Section

Jean Paul Boucher, Douglas F. Rhodes.

New England Section

Richard R. Bock, Daniel Paul Capriotti, Francis G. Haggerty, Melvin J. Weiner.

Northern California Section

Nathaniel Lewis Hawks, Robert W. Kraft, Ernest O. Retherford, Roy Eugene Van Sickle, John C. Wagner.

Northwest Section

Donald Robert Duncan, J. H. Foster, Kendall W. Macdonald, Jerry A. Roquet.

Oregon Section

Ned Ransom Powley, II.

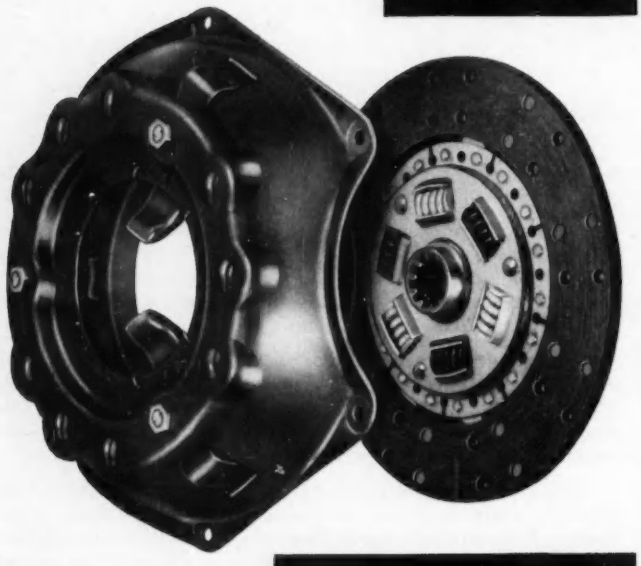
Philadelphia Section

Bona Odell Brown, Robert P. Clatterbuck, William S. Flogaus, Joseph Paul Kubik, John Albert Lamb, Arthur

Continued on Page 146

Engineered by Borg & Beck...

. . . means
MAXIMUM PERFORMANCE
MINIMUM MAINTENANCE!



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BORG & BECK®
CLUTCHES...FOR THAT VITAL SPOT WHERE POWER TAKES HOLD OF THE LOAD!

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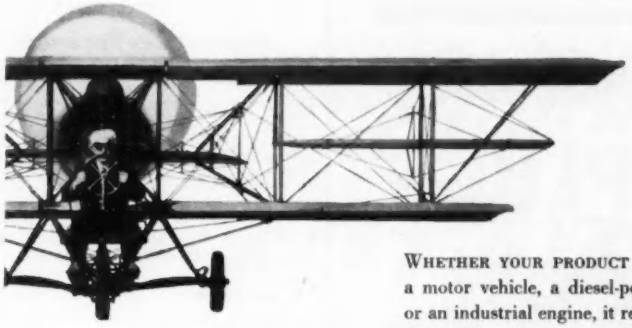
Chicago 38, Illinois



WHETHER YOUR PRODUCT is a plane, a motor vehicle, a diesel-powered truck or boat or an industrial engine, it requires engine parts that assure maximum performance and dependability.

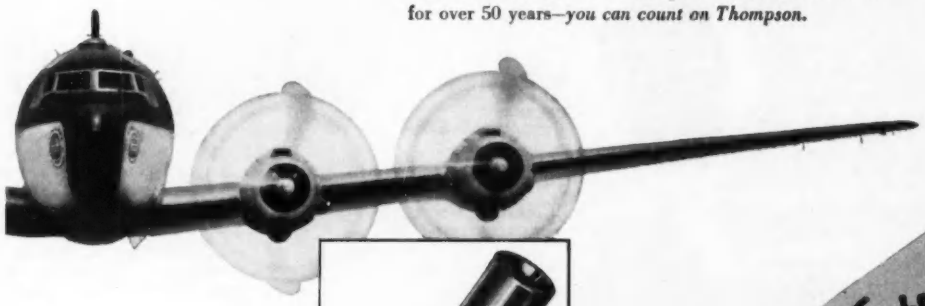
For 50 years Thompson Products has been making precision parts. Its engineers have perfected such vital engine parts as piston pins for the powerful, dependable aircraft engines of today. The same metallurgical knowledge and manufacturing skill are used in making the piston pins for the mass-produced cars, trucks and tractors of today.

Along with piston pins, Thompson's Special Products Division makes valve seat inserts, cylinder sleeves,

Engine performance you can take for granted!

cast iron pistons and valve retainer caps and locks.

If you are having trouble with engine parts— if you need a better, more dependable supplier, write or call *Special Products Division, Thompson Products, Inc., 2196 Clarkwood Road, Cleveland 3, Ohio.* You'll soon learn what car and plane makers have known for over 50 years—*you can count on Thompson.*



Piston Pin made by Thompson's Special Products Division used in some of America's finest aircraft engines.

You can count on Thompson
SPECIAL PRODUCTS DIVISION

LISLE Magnetic DRAIN PLUGS

Guarantee service costs can be reduced substantially by installing Lisle Plugs as original equipment in transmission, overdrive, crankcase and rear axle.

A permanent magnet attracts and holds abrasive metal particles that flake off moving parts and circulate in the oil. Lisle Plugs greatly reduce this common cause of premature wear.

Replace Ordinary Plugs with LISLE PLUGS

To Remove IRON and STEEL Particles from Oil

SEE *for yourself. Sample* LISLE PLUGS *will be sent you FREE for testing. Just state type and size of plug desired.*

LISLE Corporation
CLARINDA, IOWA

Applications Received

continued

Clinton Miller, William Virgil Rich, James Martin Sweeney, Philip B. Taylor, Jr., Daniel Bernard Weinstein.

Pittsburgh Section

Alvin B. Esterberg, A. Nevin Jones, William L. Mosenson, Elgin Oehler.

St. Louis Section

Walter Wayne Barber, George K. Gilbert, Hbt. Rich Grumman, John J. Kimutis, Robert S. Lemen, Thomas D. Spragle, Clarence Waeltz.

San Diego Section

Thomas H. Chadwick, Bernard Gross, John B. Hurt, Warner S. Lowe, George Scott Oliver, Robert Gordon Sharp, Ernest G. Stout, Jerry B. Torrance, Wallace W. Withee.

Southern California Section

Marshal S. Caley, Arthur M. Cole, Walter K. Deacon, Edwin L. Durham, Richard J. Hoard, Peter E. King, John Andrew McAnulty, C. Robert Nattress, Earl G. Peters, Clifford M. Reno, Cecil W. Roenfeldt.

Southern New England Section

Hans J. Albrecht, John C. Daniels, John H. Johnson.

Texas Section

James W. Amidei, L. W. Conine, Lloyd M. Cregor, R. L. England, Jr., John W. Ludwig, William P. McGriff, II, Horace E. Vail.

Twin City Section

Irvin C. Buethling, James A. Butcher, Duane C. Eckstedt, John Everette Langdon, Robert Paul Lindeman.

Washington Section

Louis Booth Feldman, George W. Haldeman, Laurence P. Mirick, Frank Sales Pohanka, Jr., Arnold J. Tenner.

Western Michigan Section

Stanley J. Bourdon, Jr., Ronald C. Groves, Charles T. Hardenburg, Edward Orent, Elias W. Scheibe.

Outside of Section Territory

Leslie L. Cahan, Ray E. Carter, D. E. Crooker, Walter E. Davis, Seymour J. Feinberg, Christian Hess, Monroe H. Kessler, William H. Leinbach, Henry John Rymes, Philip H. Snoberger, William E. Stoffregen, Ernest D. Vernon, Jr.

Foreign

Lucien Bignon, France; Alan Colin Campbell Orde, England; Nisbet Walter Silcock, Australia.

Announcing the NEW

TIMKEN-DETROIT

DUPLEX

BALANCED BRAKES

The new Timken-Detroit Duplex Brakes are simpler, more efficient two-shoe brakes in which both shoes are equally effective in either forward or reverse directions. Built for use with hydraulic, air or mechanical actuation, the Duplex Series Brakes are companion brakes to the famous Timken-Detroit Dual-Primary Series Brakes used on medium and heavy-duty trucks.

WRITE FOR THE FULL FACTS TODAY. AN INFORMATIVE, ILLUSTRATED FOLDER WILL BE MAILED ON REQUEST.

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TDA BRAKE DIVISION
THE TIMKEN-DETROIT AXLE COMPANY
ASHTABULA, OHIO
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PLANTS AT: DETROIT AND JACKSON, MICH. • OSHKOSH, WIS. • UTICA, N. Y. • ASHTABULA, KENTON AND NEWARK, OHIO • NEW CASTLE, PA.

For Replacement—

Buy only
TIMKEN-DETROIT
Torsion-Flow
AXLE SHAFTS
(patented)

Guarantee

Effective Aug. 1, 1952, any Timken-Detroit Torsion-Flow Axle Shaft is guaranteed for 100,000 miles of operation or for 3 years, whichever occurs first, against defective material or workmanship (but not against accident or abuse) when these shafts are used on a vehicle the specifications of which have been approved by our engineering department.

Authorized dealers of trucks equipped with Timken-Detroit Axles will replace any broken Timken-Detroit Torsion-Flow Axle Shaft upon presentation of the axle shaft and the proper filing of replacement form.

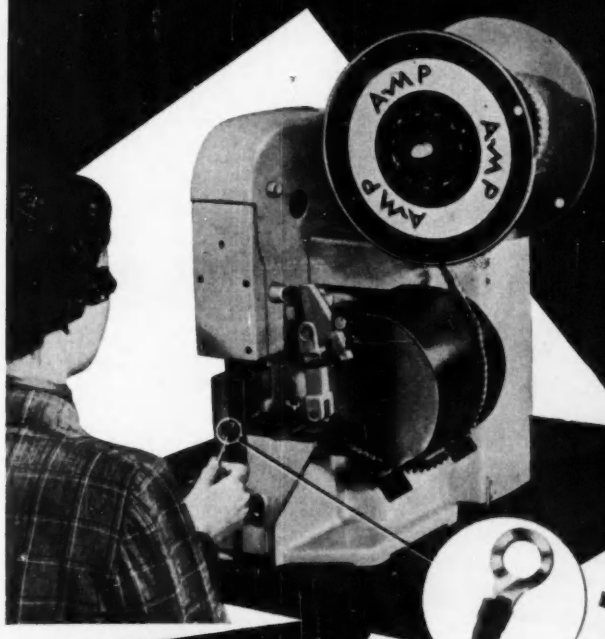
GUARANTEED for 100,000 MILES!

or 3 years, whichever occurs first

If your trucks are Timken-Detroit equipped, here are two good reasons why you should replace axle shafts with *genuine* Timken-Detroit Torsion-Flow Axle Shafts! First, the replacement shaft is identical in every respect to the original equipment you bought. Second, Timken-Detroit Torsion-Flow Axle Shafts are backed with an absolute *guarantee*—the only one of its kind in the industry. If your shaft breaks down within 100,000 miles or 3 years, whichever occurs first, you get a new one free of charge. Check the guarantee printed on this page for the full facts. And remember, whenever your Timken-Detroit Axles need replacement parts look for any truck dealer who sells Genuine Timken-Detroit Axle Parts. You'll find he's a good man to do business with.

Genuine
TIMKEN
Detroit
AXLE PARTS
The Accepted D T A Standard
TRADE MARK REGISTERED

Look for this sign!



the *Only* automatic wire terminator *Proven* by years of continuous service!

Every year more manufacturers with large mass production requirements have chosen A-MP—now more than 100 million A-MP terminals are pressure-crimped to wires every month.

This new A-MP automatic terminator provides increased speed* of application to the other proven advantages of solderless terminals.

SEND FOR SPECIAL AUTOMATIC MACHINE CATALOG!

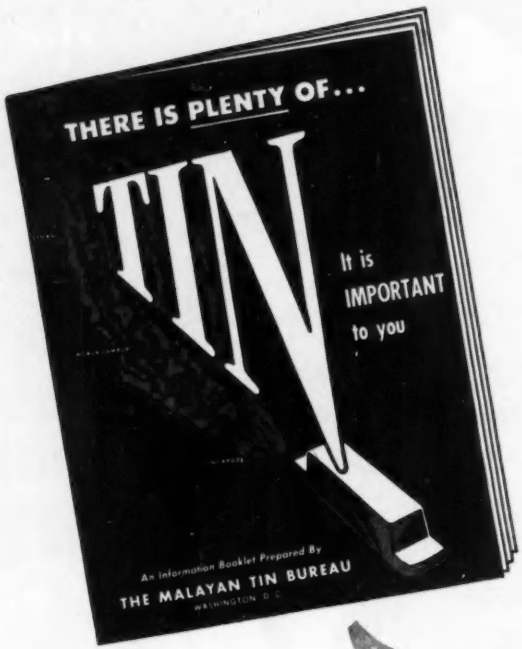
Non-insulated A-MP terminals and connectors can be applied to rates up to 4,000 terminations per hour!

WRITE FOR A DEMONSTRATION IN YOUR PLANT!

AMP Trade-Mark Reg. U. S. Pat. Off.

A-MP

AIRCRAFT-MARINE PRODUCTS, INC.
2100 Paxton Street, Harrisburg, Pa.



HERE ARE THE REAL FACTS ABOUT TIN

1 THERE IS PLENTY OF IT

2 IT IS ECONOMICAL TO USE

Rumors and myths about a "scarcity" of tin, about "high prices" for tin, have given the American people wrong impressions. This is a potentially dangerous situation.

You should know the truth.

To help you get it, we have prepared a 20-page booklet giving detailed facts and figures that bring the over-all picture into sharp focus. You want—you *need*—the important information this booklet can give you. A moment now to clip this coupon will bring a copy to your desk. May we hear from you?

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THE MALAYAN TIN BUREAU

Department 421

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There Is Plenty of Tin in Malaya

THE MALAYAN TIN BUREAU
Department 421
1028 Connecticut Ave.
Washington 6, D.C.

Gentlemen:

Please send at once my copy of the 20-page booklet, "There Is Plenty of Tin."

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Firm Name .....

Street .....

City ..... State .....

Proved and approved
for over 13 years

SAGINAW *Hydraulic* POWER STEERING

*Now available on 1952 model Oldsmobiles, Buicks and Cadillacs

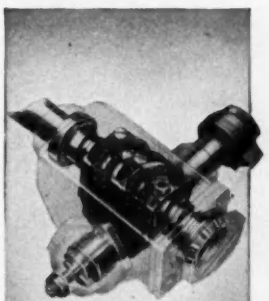
Since 1939, when it was introduced, Saginaw hydraulic power steering has proved its worth over and over again on thousands of commercial vehicles.

Now Saginaw hydraulic power steering is available on passenger cars! And already it has won wide acceptance, for "there is no steering like power steering . . . and no power steering like Saginaw *hydraulic* power steering."

This new application of the Saginaw hydraulic power steering principle is amazingly simple in design . . . has fewer moving parts, fewer parts in all. It retains the natural feel of ordinary steering at moderate speeds, but makes a spectacular reduction in steering effort at low speeds or for parking.

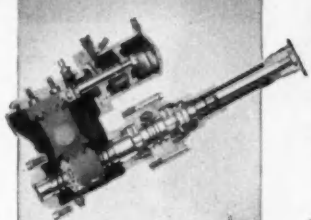
For further information, write Saginaw Steering Gear Division of General Motors.

IF IT'S EASY TO STEER . . . IT'S A SAGINAW GEAR



RECIRCULATING BALL PRINCIPLE

Saginaw's famous recirculating ball principle provides friction-free operation that is unique in the industry. It is a principle proved in over a million automotive steering gears.



HYDRAULIC POWER STEERING

A hydraulic booster multiplies driver steering effort, makes it easy to swing the wheel of the biggest car traveling at any speed—or even when standing still.

*Optional equipment at extra cost

Saginaw
STEERING GEAR DIVISION
General Motors Corporation, Saginaw, Michigan

SSG PRODUCTS

STEERING GEAR ASSEMBLIES • STEERING LINKAGE ASSEMBLIES • PROPELLER SHAFTS • DIESEL ENGINE AND AIRCRAFT PARTS

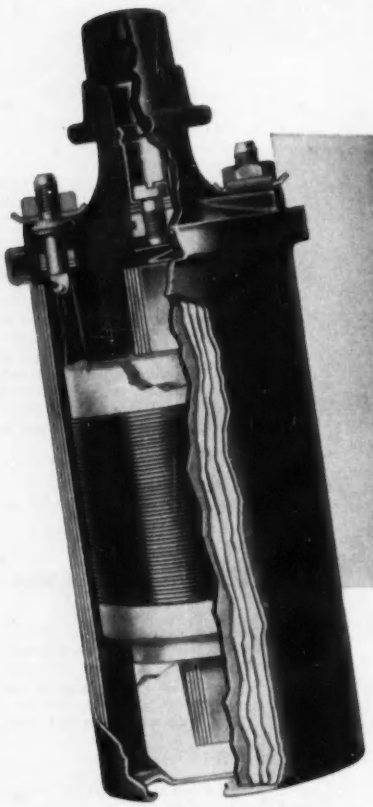
HIGH QUALITY and HIGH PRODUCTION

go hand in hand at DELCO-REMY!

Special machines contribute greatly to the uniform high quality of Delco-Remy products—and to the high rate of production as well. These machines are designed and built by the Process Engineering Department of Delco-Remy to perform the most intricate operations smoothly, swiftly, and within extremely close tolerances.

Typical of such equipment is the battery of ignition coil winding machines, a few of which are illustrated. Their job is a delicate one—to wind ignition coils with speed and precision impossible to attain with other winders. What's more, these machines eliminate most of the manual controls of earlier models, perform 95 per cent of the job automatically.

Yes, quality and production go together at Delco-Remy, thanks to these and other machines custom-designed for their jobs.



Cut-away view showing assembled ignition coil winding.

Delco-Remy
DIVISION, GENERAL MOTORS CORPORATION
ANDERSON, INDIANA

WHY DELCO-REMY IGNITION COIL WINDING MACHINES GUARANTEE A UNIFORM PRODUCT

1. Number of turns of wire is accurately controlled.
2. Finished size of coil is held within close tolerances. (Allows snug assembly in coil case.)
3. Uniform tension is held on wire during winding. (Minimizes wire breakage and improves uniformity of layers.)
4. Several coils are wound simultaneously on the same spindle and cut apart automatically.
5. Automatic controls stop machine instantly if wire breaks or in case of other failure that would result in a defective coil.

AUTOMOTIVE, TRACTOR AND MARINE ELECTRICAL EQUIPMENT

When a high-strength steel is needed

for severe cold-formed shapes like these bumpers

Specify N-A-X HIGH-TENSILE STEEL

and get all of the requirements of SAE 950

When a material meeting the requirements of the high-strength, corrosion-resisting steels of SAE Specification 950 is used for severe cold-formed shapes, it will pay to investigate N-A-X HIGH-TENSILE steel—the low alloy steel with *built-in formability*. Its finer grain and higher hardness also result in brighter luster when ground and polished for plated parts.

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division
Ecorse, Detroit 29, Mich.

NATIONAL STEEL CORPORATION

NATIONAL OIL SEAL LOGBOOK

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California office

Versatile standard-design National Oil Seals save time and avoid production "log-jams"

You save engineering time, get faster delivery and minimize tooling costs when you utilize standard-design National Oil Seals. National offers over 1,000 such seals, including virtually all commonly used types in standard shaft and bore sizes.

One of the most widely used standard-design seals is the time-tested National 50,000 series seal (Fig. 1). This design has a precision-made steel outer case and an accurately spring-tensioned sealing member of leather treated by an exclusive National process. It is particularly suited to heavy duty applications where dust and dirt conditions are severe. These seals retain lubricant in their sealing member and can thus run "dry" for some time without damage. This same type of sealing member is available as a dual tandem, dual opposed or external seal (Fig. 2), or in combination with felt or springless leather auxiliary members.

Fig. 1. National 50,000 Leather Seal.

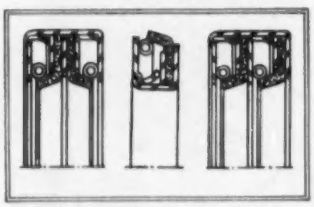


Fig. 2. L. to r., National 70,000, 80,000 and 90,000 Leather Seals.

The basic National 50,000 design is also offered as the National 50,000-S Syntech* seal (Fig. 3). This design has a spring-tensioned sealing member of National Syntech (synthetic rubber). This seal is in wide use throughout industry on automobiles, trucks and buses; electric motors, generators, pumps and other machinery. National Syntech is unaffected by most industrial fluids and is designed to operate over a wide range of temperatures and at shaft speeds up to 3,500 fpm. This design is available as a dual opposed, tandem or external seal, or in combination with felt or springless Syntech auxiliary members (Fig. 4).

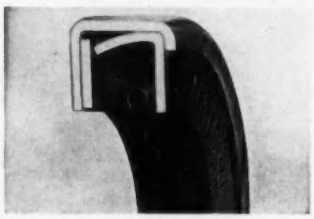


Fig. 3. National 50,000-S Syntech Seal.

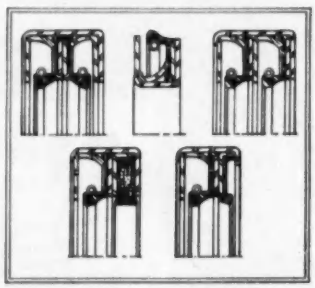


Fig. 4. Top, l. to r., National 70,000-S, 80,000-S, 90,000-S Syntech Seals. Bottom, l. to r., National 10,000-S Syntech-felt and National 20,000-S Syntech Seal.

Standard National designs also include many Syntech rubber-covered seals. Typical examples are shown in Fig. 5.

National Oil Seals shown here are suited to many different applications, from compact chain saws to giant earth-moving equipment. Next time you specify seals, why not talk to the National Oil Seal Engineer in your area? Chances are he can show you how a standard-design National seal can solve your problem.

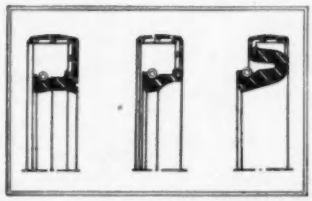


Fig. 5. L. to r., National 320,000, 350,000 and 370,000 Syntech Seals.

"Let Your Decision be Based on Precision"

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City, Calif.; Downey (Los Angeles County), Calif.; Van Wert, Ohio

2809

*Trade Mark Registered

CALL IN A NATIONAL FIELD ENGINEER

BUFFALO, N. Y. . . . *Room 1124, Prudential Bldg., Mohawk 9222*
CHICAGO, ILL. . . . . *Room 4113 Field Building, Franklin 2-2847*
CLEVELAND, OHIO . *210 Heights Rockefeller Bldg., Yellowstone 2-2720*
DALLAS, TEXAS . . . *30½ Highland Park Village, Justin 8-8453*
DETROIT, MICH. . . . . *726 Lothrop Avenue, Trinity 1-6363*
DOWNEY (Los Angeles Co.), CALIF. . *11634 Patton Rd., Topaz 2-5166*
MILWAUKEE, WIS. . . *647 West Virginia Street, Broadway 1-3234*
NEW YORK CITY, N. Y. . *122 East 42nd Street, Murray Hill 6-0171*
PHILADELPHIA, PA. . . *401 North Broad Street, Bell-Walnut 3-4997*
REDWOOD CITY, CALIF. . . *Broadway and National, Emerson 6-3861*
RICHMOND, VA. . . . . *216 South Fifth Street, Richmond 2-5476*
ROCHESTER, N. Y. . . . . *95 Landing Road, Culver 3531*
WEST SPRINGFIELD, MASS. . . *1025 Elm Street, Springfield 3-1891*
SYRACUSE, N. Y. . . . . *P.O. Box 1224, Baldwinsville 662*
WICHITA, KANSAS . . . . *519 South Broadway, Wichita 2-6971*

Compact Power for Power Steering

Eaton Rotor Pumps with Flow-Control

Where space is at a premium, the Eaton high-speed power unit provides the advantage of small, compact design. As a pioneer in the development of pumps with flow control for hydraulic power steering, the Eaton Pump Division offers unequalled facilities in both design and production. If you are considering power steering, there are distinct benefits in permitting our engineers to work with yours in the early design stages.

EATON MANUFACTURING COMPANY

GENERAL OFFICES: CLEVELAND, OHIO

EATON *Pump Division* . 9771 French Road . Detroit 13, Michigan

NOW YOU CAN WITH STERLING'S NEW AMA

FIT PISTONS TO LESS CLEARANCE

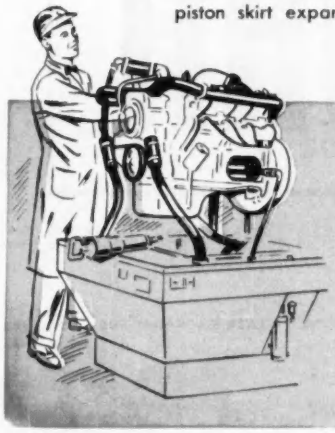
ZING

CONFORMATIC* PISTON!

Without Danger of Scuffing or Seizing...

"... quieter engines ... no more cold slap ... reduced friction ... no loss of strength or conductivity ..." No wonder *Conformatic* is the talk of the trade! This revolutionary new aluminum piston is made to be fitted at .001 clearance or less because an anchored steel tension member actually makes the piston skirt expansion *conform* to cylinder expansion. Long-range performance tests have shown this *Conformatic* control to be so accurate that pistons fitted at .001 have no cold slap at −20°F.—and no seizing or scuffing at 200°F.

Think of what this new piston idea can mean to you! For complete information and technical data, write or phone —



RESULTS OF 1200-HOUR CYCLE TEST

In recent cycle tests made by one of the largest automotive manufacturers, Sterling *Conformatic* Pistons were fitted into a stock engine at .0005 clearance. After operating the engine for 1200 hours, approximately 50% of which were run at 4000 r.p.m. or over, full load, full throttle, *the Conformatic Pistons were pronounced* perfect!

STERLING PISTONS

*T.M. Reg., Patent Applied for

STERLING ALUMINUM PRODUCTS INC. • St. Louis, Missouri

jet power packages by

ROHR

WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES

ROHR AIRCRAFT CORPORATION CHULA VISTA AND RIVERSIDE CALIFORNIA

Acceptance

Speaking of Chrome . . .

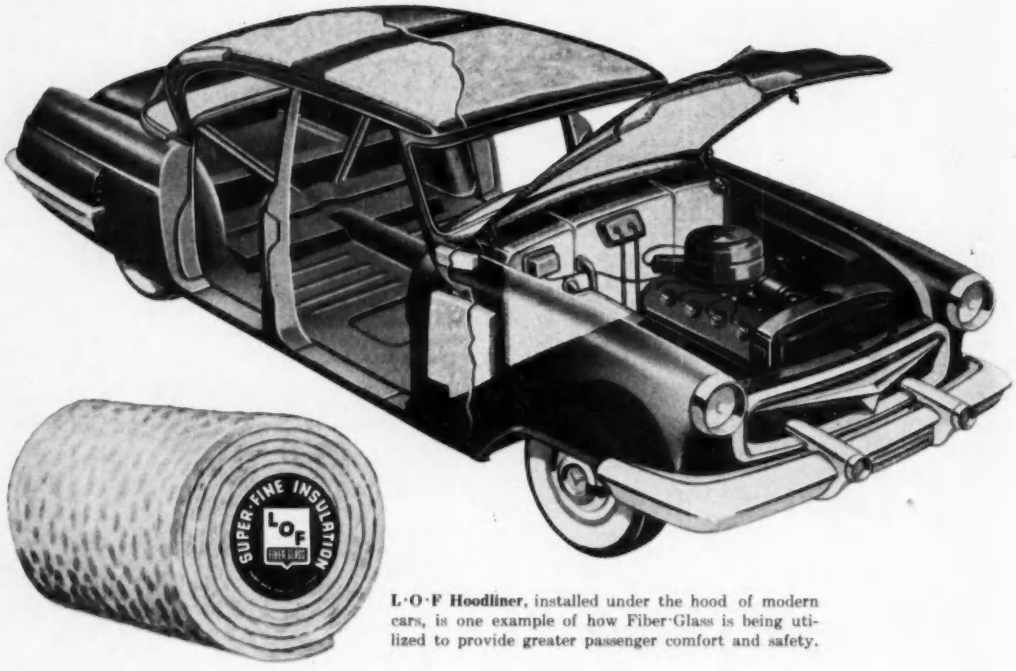
Sealed Power

Chrome-Faced
Piston Rings
are used
as original equipment by 23 (*yes, twenty-three*)
leading
engine manufacturers

Sealed Power Piston Rings

SEALED POWER CORPORATION • MUSKEGON, MICHIGAN

Sole manufacturers of KromeX Ring Sets, MD-50 Steel Oil Ring, Full-Flow Spring, Flex-S Flexible Oil Ring, and GI-60 Groove Inserts. Leading producer of Automatic Transmission Rings and Non-Spin Oil Rings.



L·O·F Hoodliner, installed under the hood of modern cars, is one example of how Fiber·Glass is being utilized to provide greater passenger comfort and safety.

How to increase passenger comfort and safety

L·O·F Fiber·Glass provides fire-resistant sound and thermal insulation for cars and trucks

MANY OF today's finest cars are insulated throughout with L·O·F Fiber·Glass for greater passenger comfort. For example, L·O·F Hoodliner, installed under the hood, reduces high-frequency engine sounds, tire whine and air-stream whistle.

Fiber·Glass Hoodliner is lightweight, flexible and can be easily installed. It has excellent thermal- and sound-insulating properties, and is fire-resistant.

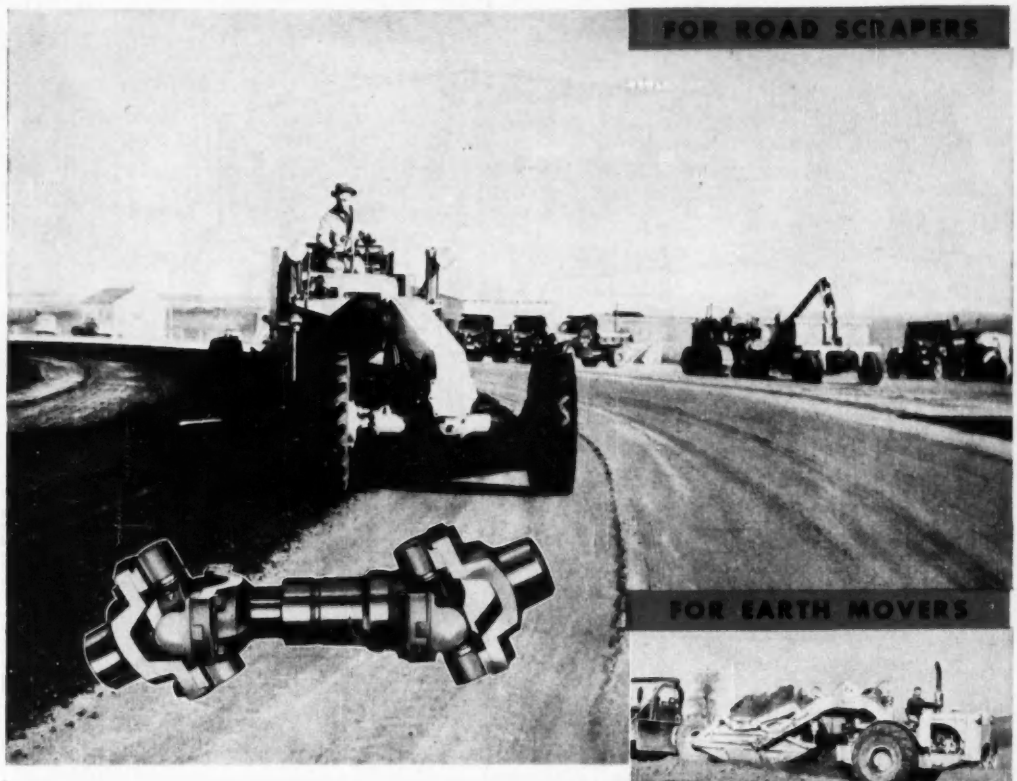
L·O·F Fiber·Glass is also supplied as superior insulation for roof liners, on fire walls, under package trays and as dash liners. You can count on Libbey·Owens·Ford—with over 50 years' experience—to meet your schedules *right on time.*

For more information, call L·O·F's Detroit office, 610 Fisher Building, Trinity 5-0080. Or write, wire or phone Libbey·Owens·Ford, Dept. F·G 6122, Nicholas Building, Toledo 3, Ohio, and obtain names of suppliers of Hoodliner Kits.

L O F GLASS
PLASKON
L O F FIBER-GLASS

LIBBEY·OWENS·FORD GLASS COMPANY
FIBER·GLASS DIVISION

FIBER·GLASS

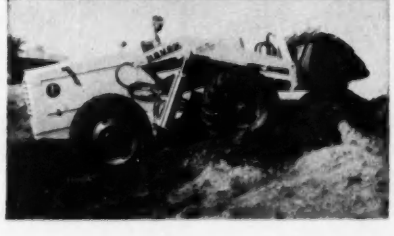


FOR ROAD SCRAPERS

FOR EARTH MOVERS

FOR TRENCH DIGGERS

FOR EARTH LOADERS



MECHANICS JOINTS

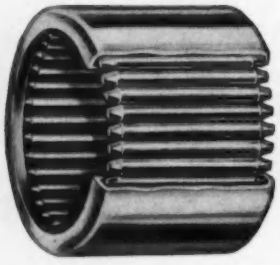
Are Used on the TOUGH JOBS

Designers with JOINT problems have learned to rely on MECHANICS. Where joints must run all day at constant angles up to 45°—where there are severe shock loads—where wide angles and long slip are common—and where dirt and/or moisture are continually present — MECHANICS Roller Bearing UNIVERSAL JOINTS are the accepted solution. Lubrication is so tightly sealed in that dirt and moisture cannot enter. If you have a "tough" joint problem, make use of MECHANICS engineers' wide experience.

MECHANICS
UNIVERSAL JOINT
DIVISION
Borg-Warner
2022 Harrison Ave.
Rockford, Ill.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS
For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

tight quarters are no problem



Torrington Needle Bearings have smaller OD in relation to rated radial load capacity than any other type of anti-friction bearings.

In many products, compact Needle Bearings allow reductions in size and weight of housings and related assemblies. In others, they permit the use of larger, stronger shafts without increasing housing bores.

Whatever *your* space problem, it will pay you to investigate the combination of high capacity and small OD offered by Torrington Needle Bearings. Our engineers will be glad to assist you.

THE TORRINGTON COMPANY
Torrington, Conn. South Bend 21, Ind.
District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* **BEARINGS**

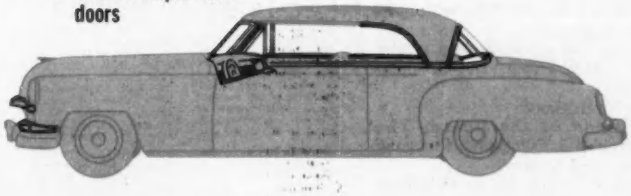
Needle • Spherical Roller • Tapered Roller • Straight Roller • Ball • Needle Rollers

MOTOR PRODUCTS

A DEPENDABLE GUIDE to the FINEST in METAL FINISHING

The name of "Motor Products" has reflected quality workmanship for more than 35 years.

★ Windshield mouldings
★ Window ventilators
★ Garnish mouldings
★ Glove compartment doors



★ Radiator grilles
★ Instrument panels
★ Body mouldings

MOTOR PRODUCTS CORPORATION
11801 Mack Avenue Detroit 14, Michigan

Announcing

General Motors Better Highways Awards

$194,000 in awards for the most practical solutions to America's critical highway problem

Every American is intensely aware of the inadequacy of our roads and streets to meet today's highway transportation needs. Yet too few have given thought to a practical solution.

It is a difficult problem, because modern highways cost a lot of money. *But lack of them is costing even more!*

To encourage all Americans to think about this critical situation and come forward with practical solutions, General Motors is instituting the GM Better Highways Awards for the best essays submitted on the following subject:

"How to Plan and Pay for the Safe and Adequate Highways We Need"

A total of 162 State, Regional and National Awards will be given for those entries which are considered best by an independent board of five judges. The following have accepted appointment to the board:

NED H. DEARBORN
President, National Safety Council

THOMAS H. MACDONALD
Commissioner, Bureau of Public Roads, U.S. Department of Commerce

CURTIS W. MCGRAW
Chairman of the Board, The McGraw-Hill Publishing Company

DR. ROBERT G. SPROUL
President, University of California

B. D. TALLAMY
Superintendent, New York State Department of Public Works and President, American Association of State Highway Officials.

Entries will be judged for originality, sincerity and practical adaptability—not on literary merit.

To help you in preparing your entry, background information about the present highway crisis has been compiled in "The General Motors Better Highways Awards Facts Book." A copy, containing official contest entry form, will be sent you on request, or can be obtained from any General Motors car or truck dealer.

Contest closes midnight, March 1, 1953. Winners will be publicly announced as soon thereafter as the judging can be completed.

CONTEST RULES

1. WHO MAY COMPETE: Any individual who is a resident of a state of the United States or the District of Columbia may compete for an award, except Contest Judges and the members of their immediate families.

2. WHAT IS TO BE SUBMITTED: Each contest participant shall submit an original essay, with any supporting material or data the participant may desire, on the subject

"How to Plan and Pay for the Safe and Adequate Highways We Need"

3. HOW, WHEN, AND WHERE ENTRY IS TO BE SUBMITTED: To be eligible for award consideration, each essay must be submitted with an official entry blank which may be secured from any General Motors car or truck dealer or by writing to

General Motors Better Highways Awards
General Motors Building
Detroit 2, Michigan

Essays may only be submitted with a completed official entry blank, and must be mailed to the address immediately above.

To be eligible for award consideration, a contest entry must be postmarked not later than midnight, March 1, 1953, and must be received by March 14, 1953.

4. GENERAL REQUIREMENTS AND CONDITIONS CONCERNING ENTRIES: A participant by submitting an essay agrees to be bound by all rules of the contest. Each essay shall be in English, on one side of the paper only, and preferably typewritten. Illegible essays will be automatically disqualified. While brevity is suggested, no limitation is placed on the length of the essay. Participants should use the number of words they believe necessary. No essays will be returned. Upon submission, each essay and the contents and ideas therein become the property of General Motors Corporation which shall have the exclusive right to make unlimited use, in whole or in part, of the same. A participant represents by submitting an essay that its contents, in whole and in part, are original, and participant further represents that such essay has not been submitted, or in any manner disposed of, to other than General Motors Corporation.

5. AWARDS: Contents of essays will be judged for originality, sincerity, and practical adaptability. Awards in the number and amounts listed below will be made as determined by a Board of judges.

SIX NATIONAL AWARDS

First Award, $25,000; Second Award, $10,000; Third Award, $5,000; Three Honorable Mention Awards, each $3,000.

NINE REGIONAL AWARDS

For the best essay submitted from each of nine regional sections* of the United States, each $2,500.

*States included in each region are listed in "The General Motors Better Highways Awards Facts Book."

147 STATE AWARDS

49 First Awards, one for each state and the District of Columbia, each $1,500.

98 Honorable Mention Awards, two for each state and the District of Columbia, each $500.

The selection of award winners will be made from all entries as a group. National award winners will be selected first and thereupon automatically eliminated from further consideration. Regional award winners will be selected next from the remaining entries and will automatically upon selection be eliminated from further award consideration. From the entries remaining after the selection of national and regional award winners, state award winners will be selected. No participant may win more than one award. In the event of ties for a particular award, or in the event that an essay of an employe of General Motors Corporation, or one of its domestic subsidiaries, is an award winner, duplicate awards will be made.

6. ANNOUNCEMENT OF AWARDS: The names of all award winners will be announced as soon as possible after the close of the contest.

7. The decision of the Board of Judges with respect to awards and all other contest matters are final and binding on each participant.

8. The contest and awards made in connection with the contest are subject to all applicable local, state, and federal laws and regulations.

THE GENERAL MOTORS BETTER HIGHWAYS AWARDS

"How to Plan and Pay for the Safe and Adequate Highways We Need"

SIX NATIONAL AWARDS

FIRST AWARD	$25,000
SECOND AWARD	$10,000
THIRD AWARD	$ 5,000
THREE HONORABLE MENTION AWARDS, each	$ 3,000

NINE REGIONAL AWARDS

For the best essay submitted from each of nine regional sections* of the United States, each	$ 2,500

147 STATE AWARDS

49 First Awards, one for every state and District of Columbia, each	$ 1,500
98 Honorable Mentions, two for every state and District of Columbia, each	$ 500

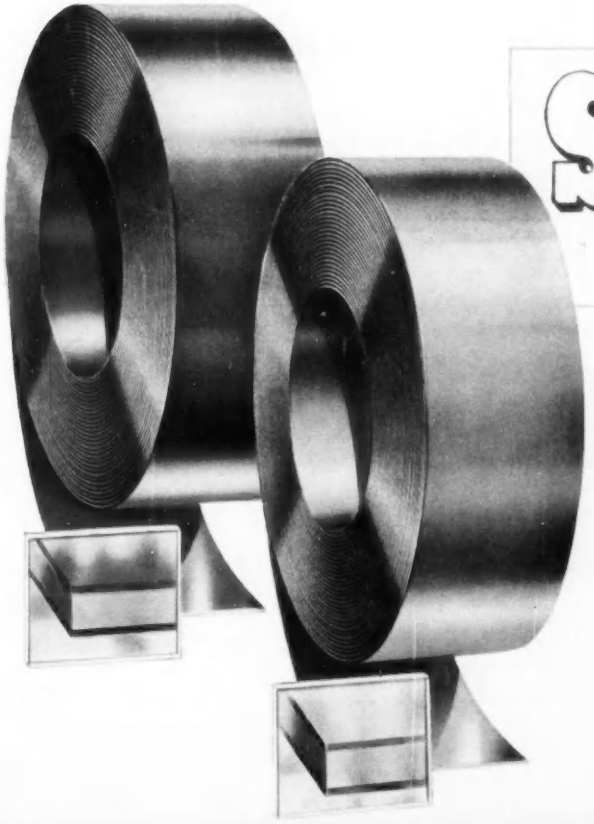
*States included in each region are listed in "The General Motors Better Highways Awards Facts Book."

Address all entries to: **General Motors Better Highways Awards, General Motors Bldg., Detroit 2, Mich.**

WHILE YOU HELP SAVE

COPPER AND BRASS

FOR DEFENSE



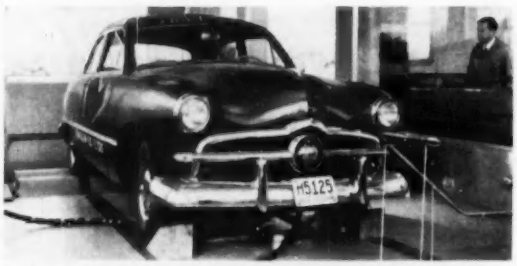
SuVeneer®
CLAD METALS

There's a two-way benefit in every coil of **SuVeneer** Clad Metals: profitable economy for you, and conservation of critical materials for defense.

The *solid* copper or brass on steel represents a saving of 70% to 80% over equivalent gauges of the single non-ferrous metals, and brings the inner strength of steel to your copper or brass product applications. The metals are bonded inseparably—you use your regular fabricating methods with this time-proved product. • Let us cooperate with you.

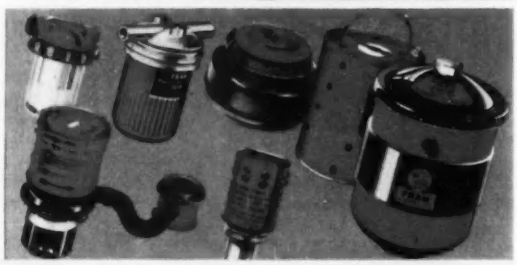
Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

FRAM is FIRST in the Filter Industry *here's why*



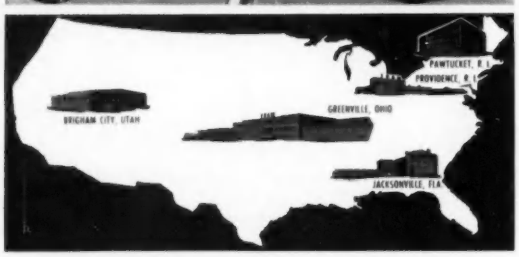
Better Research, Development and Engineering Facilities

Within the finest research and development laboratories in the automotive filter field, alert Fram scientists and technicians constantly develop and perfect Fram products. After exhaustive performance tests in the laboratory, new Fram products and new developments of existing products are given intensive workouts on the Fram test fleet and in the famous Fram Dust Tunnel at Dexter, Michigan.



A Complete Line of Automotive Oil, Air, Fuel and Water Filters

Complete engine protection from the outside and from within the engine itself is vitally important to continued top performance. Fram Oil, Air, Fuel and Water Filters and Crankcase Ventilators lengthen the life of engines, decrease maintenance, cut repair bills and increase mileage between overhauls . . . saving motorists time, trouble and money.



Strategically Located Plants Give You Better Service

Widespread manufacturing facilities offer you efficient, high-speed production and fast delivery. The Manufacturers Sales Division, located in Dexter, Michigan, is fully staffed to provide the automotive industry with fullest cooperation in meeting any and all filtration requirements. FRAM CORPORATION, Providence 16, R. I. *Plants in:* Pawtucket, R. I.; Greenville, Ohio; Jacksonville, Fla.; Brigham City, Utah. *In Canada:* J. C. Adams Co., Ltd., Toronto, Ontario.

FRAM
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Here's why:
Laboratory tests, conducted under rigidly controlled conditions, prove that Fram Cartridges trap from 69% to 114% more dirt than other cartridges tested. Your engines deserve the best . . . and the *best* is *FRAM!*

Manufacturers of . . .

FRAM OIL & MOTOR CLEANERS ★ FRAM FILCRON REPLACEMENT CARTRIDGES ★ FRAM CEL-PAK REPLACEMENT CARTRIDGES ★ FRAM FILTRONIC REPLACEMENT CARTRIDGES ★ FRAM CARBURETOR AIR FILTERS ★ FRAM GASOLINE FILTERS ★ FRAM CRANKCASE AIR FILTERS ★ FRAM POSITIVE CRANKCASE VENTILATORS ★ FRAM RADIATOR & WATER CLEANERS ★ FRAM FUEL OIL FILTERS FRAM INDUSTRIAL OIL AND FUEL FILTERS ★ FRAM SEPARATOR-FILTER FOR IMMISCIBLE LIQUIDS ★ FRAM CUSTOM-DESIGNED FILTERS FOR SPECIALIZED APPLICATIONS.

MORAINE-400 Bearings

When you include Moraine-400 bearings in your plans, bearing length is no longer a limiting factor in automotive engine design. If the shaft diameter is sufficient to carry the torque and journals are long enough for good oil-hole design, the resulting bearing areas will be ample to carry the load.

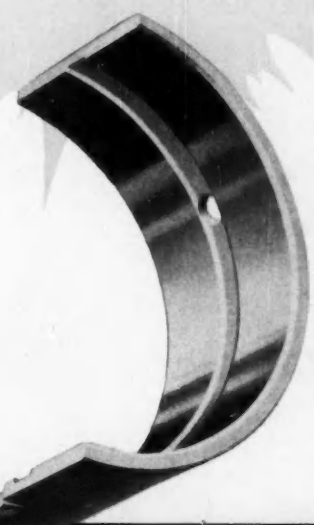
Corrosion resistance is improved; embeddability and conformability are more than sufficient to meet conditions imposed by today's engines; load-carrying capacity is amazingly greater. To prove the toughness of the Moraine-400, we reduced bearing area by one-half—more than doubling the load—and ran an engine at full throttle for 100 hours. At the end of that test—as at the end of *all* tests—the bearings were in excellent condition.

Moraine-400 bearings are readily interchangeable with the bearings you're now using and are suitable for Tocco or oil-hardened shafts.

We will soon reach volume production on Moraine-400 bearings. Whether you want to increase the efficiency of your present engines, or remove design limitations from your engines of the future, it will pay you to look into the Moraine-400 *now*.

Moraine-400 is made by the manufacturers of the famous Durex-100 bearings—now used as original equipment on many of the nation's finest cars and trucks.

HERE IS TOMORROW'S BEARING —TODAY!



MORAINE PRODUCTS
Division of General Motors
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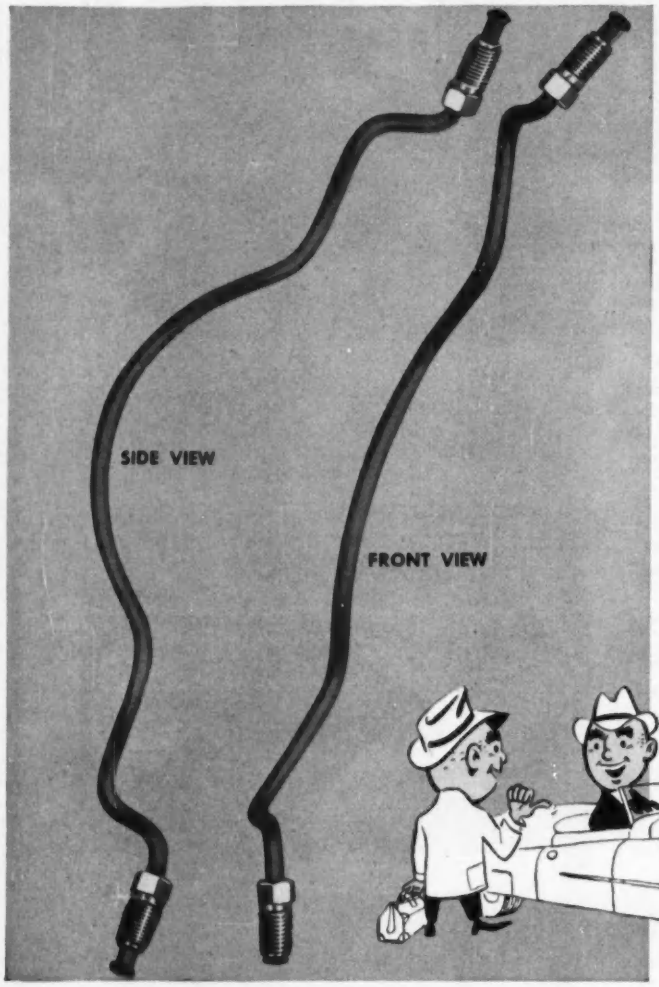
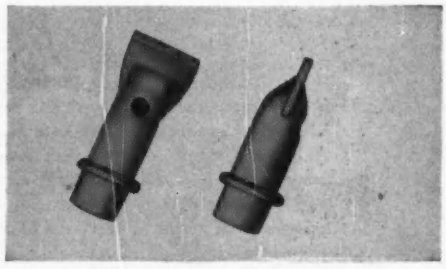


1. FABRICATION SAVINGS

Bundy engineers help pare fabrication costs. An example is the automotive brake tube shown at left. The proximity of the small-radius bends to one another made bending the tube without distortion difficult. Yet Bundy engineers went to work, came up with a *single* fixture to do the complete job without distortion. The result: total fabricating time reduced, costs lowered. These engineering skills are always at *your* disposal when you specify Bundyweld.



2. COST SAVINGS

Though it's less than 1¼" long, the timing-gear oiler tube shown above calls for three fabrication steps: piercing, flattening and upsetting. Bundy engineers were able to combine all steps into a *single* press operation. More, in that single operation *two* parts are produced simultaneously. The result is an impressively low cost-per-unit on a high-volume order. More, savings like this are passed right along to you as a Bundy customer.

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . . continuously rolled twice around laterally into a tube of uniform thickness, and passed through a furnace. Copper coating fuses with steel. Presto . . . Bundyweld, double-walled and brazed through 360° of wall contact.

NOTE the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Bundy Tubing Distributors and Representatives: Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • **Chattanooga 2, Tenn.:** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • **Chicago 32, Ill.:** Lapham-Hickey Co., 3333 W. 47th Place • **Elizabeth, New Jersey:** A. B. Murray Co., Inc., Post Office Box 476 • **Philadelphia 3, Penn.:** Rutan & Co., 1717 Sansom St. • **San Francisco 10, Calif.:** Pacific Metals Co., Ltd., 3100 19th St. • **Seattle 4, Wash.:** Eagle Metals Co., 4755 First Ave. South **Toronto 8, Ontario, Canada:** Alloy Metal Sales, Ltd., 181 Fleet St., East • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**

automotive tubing dollar

Safe, dependable performance, unequaled tubing features, and priceless engineering skills — *yours* when you specify Bundyweld Tubing.

You get safe, dependable tubing performance, *proved* by the 360,000 miles of Bundyweld used in cars, trucks, buses and tractors since 1930.

You get leakproof, lighter, stronger tubing that withstands severe shocks and has high fatigue limit. Bundyweld is the only tubing double-walled from a single strip, copper-brazed through 360° of wall contact.

You tap priceless engineering skills. Bundy engineers can often spot major savings in material and production costs during your design and planning stages. And, if you wish, Bundy will fabricate tubing parts for you — deliver them as specified exactly when you want them.

For your greatest automotive tubing buy on *every* count, specify Bundyweld.

Contact a Bundyweld Distributor (listed lower left), or write *Bundy Tubing Company, Detroit 14, Michigan*

Bundyweld® Tubing

DOUBLE-WALLED FROM A SINGLE STRIP

3. PRODUCTION SAVINGS

No matter how tricky your tubing part, Bundy skills can help iron out production kinks. Distances A and B and Diameter X in the automatic transmission part shown above each had to be held to extremely close tolerances for perfect function. Bundy engineers quickly devised a method of producing the part so precisely in just two operations that trimming Length A to size was eliminated. The result: fewer operations, greater production efficiency — with no delay in initial production setup. Bundy skills can help *you* produce your tubing requirements faster and better.

SPECIAL APPLICATION PROBLEM?

● Send us your specifications and let us quote for you. Standard's long experience assures reliable workmanship for the most unusual requirements.

Regardless whether the application is large or small, Standard can give you the long-life, trouble-free solution. Standard locknuts and lockwashers have a well-deserved reputation for the rugged endurance and precise locking that are vitally essential to long, efficient bearing assembly life.

Naturally, call on Standard for regular S.A.E. sizes of locknuts and lockwashers, too.

Write today for Standard's detailed Bulletin No. 30

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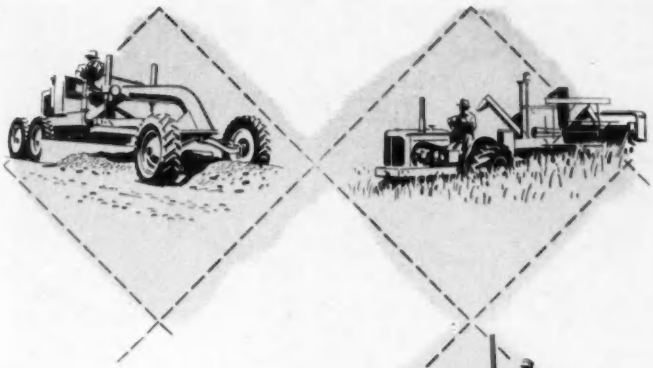
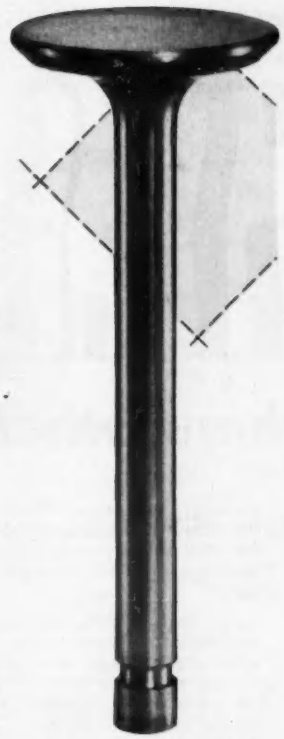


another famous name that relies on THOMPSON VALVES

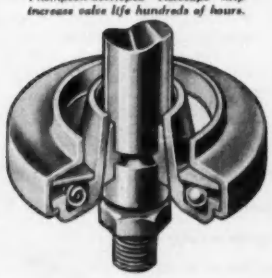
ALLIS-CHALMERS engines for farm machinery, construction equipment, and industrial jobs all depend on Thompson Valves to maintain maximum power for longer periods of time.

Thompson engineers work with Allis-Chalmers to develop valves to meet the many varied types of service that Allis-Chalmers equipment faces around the world.

Take a tip from Allis-Chalmers and other leading engine builders...count on Thompson for engineering leadership.



Thompson-developed "Rotocaps" help increase valve life hundreds of hours.



VALVE DIVISION

Thompson Products, Inc.

CLEVELAND 17, OHIO

Courtesy Lear, Inc.

in instruments where reliability is imperative

SILASTIC* works

where other materials fail

To assure maximum service life and accuracy, engineers at Lear, Incorporated, planned to protect their new vertical gyro-mechanism from corrosion by housing it in a completely inert and dehydrated atmosphere.

Sealing the housing, however, proved to be more easily said than done. Despite the most elaborate precautions, solder and flux fumes often penetrated the joint and contaminated the delicate mechanism. Once sealed, it was impossible to reopen the case without loss of the expensive cover and harness.

To both of these problems a simple and ingenious solution was found. A thin O-ring of Silastic molded to fit snugly under the cover flange is used to exclude the corrosive fumes generated in soldering a metal strip over the entire joint. The Dow Corning silicone rubber O-ring is not damaged by soldering temperatures. And, the gyro-mechanism is just as accessible for repairs as the contents of a hermetically sealed can of coffee.

Lear also uses a large ring washer of Silastic at each end of the housing to serve as resilient, shock-absorbing cushions for the apparatus at stratospheric temperatures.

And that's just one of hundreds of examples of how Silastic is used to improve the performance of products ranging from cable to traction motors, from domestic steam irons to aircraft.

*T. M. Reg. U. S. Pat. Off.

For more information about the properties or fabricators of Silastic, mail this coupon today or phone our nearest branch office.

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CASTINGS YOU CAN LIFT WITH EASE

ALCOA makes four kinds in aluminum—sand, plaster, permanent-mold and die

You don't have to look farther than your own shop to see the advantages of castings that weigh one-half, even two-thirds, less. Think how often castings are lifted while being machined, finished, assembled, and shipped. The savings in man power with aluminum castings are impressive.

Look, too, at the other commercial advantages of Alcoa Castings. Ease of machining. Corrosion resistance. High conductivity of heat and electricity.

How about price? Alcoa Castings are competitive with castings of many other metals. Their cost, finished and assembled in your product, often amounts to surprising savings over heavy metals.

We have been making aluminum castings for 41 years. We have been working with aluminum for 64 years. To aluminum's natural advantages, we add the extra measure of sound and skillful design help. Any of our four foundries or two die-casting plants, located from coast to coast, are open for your inspection. Contact your local Alcoa Sales Engineer, listed under "Aluminum" in the classified phone book.

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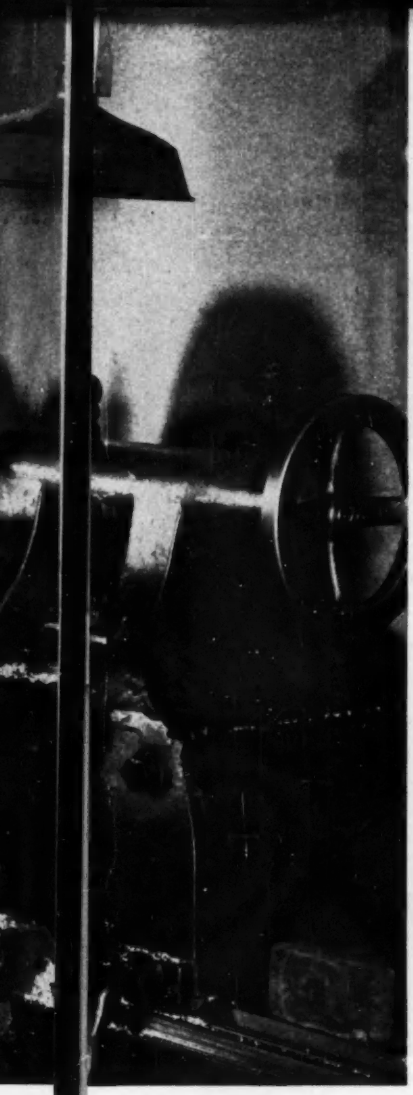
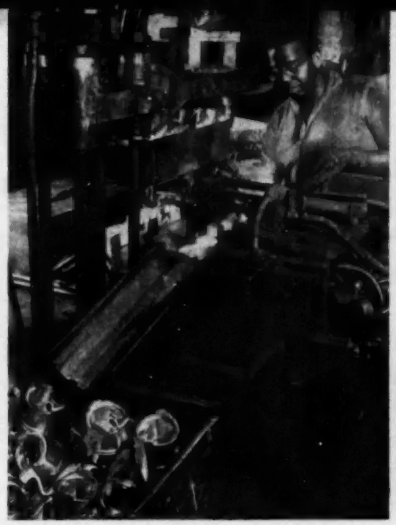
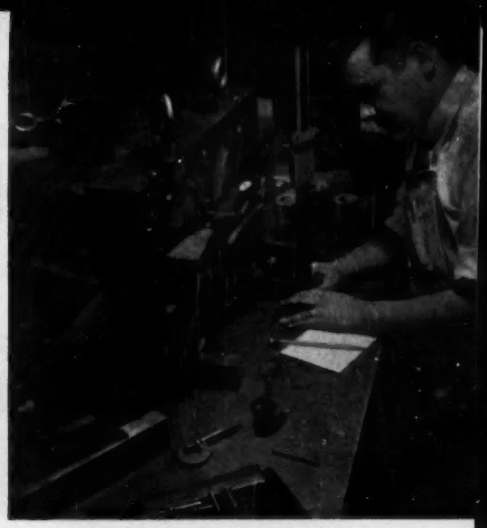
ALCOA ALUMINUM ®

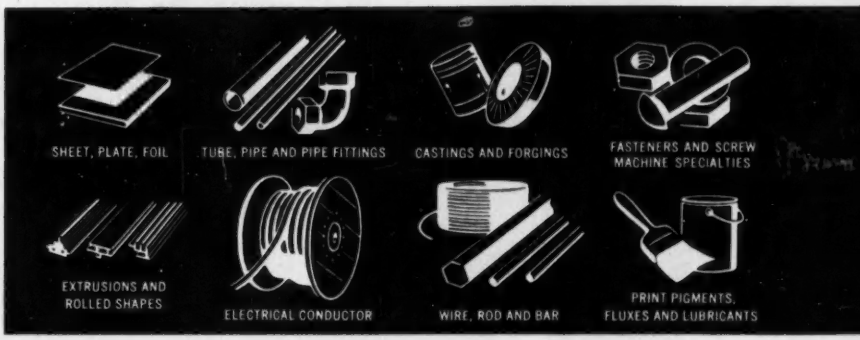




High production of permanent-mold castings in Alcoa's Cleveland foundry is illustrated by this automatic machine for making pistons.

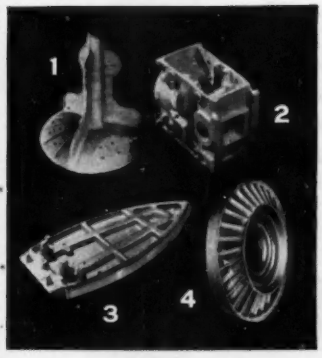


Dimensional check of a completed die in Alcoa's die-casting plant at Chicago.

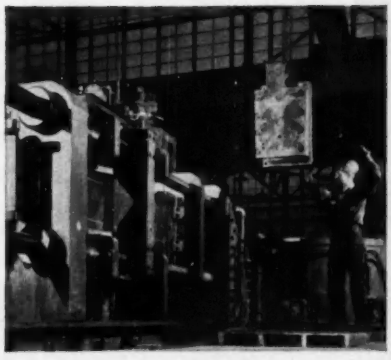


Remember, ALCOA makes "everything" in aluminum

While the sale of our products is limited by government regulations, you'll find no limitations on help in design, application, or fabrication.



Typical castings made by Alcoa. 1. Permanent-mold washing machine agitator. 2. Sand-cast machine part. 3. Die-cast electric iron soleplate. 4. Plaster-cast automotive torque converter.



Setting a die in a large die-casting machine at the Chicago plant.

A line of automatic molding machines, indicating the high production capacity for sand castings at Alcoa's Bridgeport, Conn., foundry.

not in the blueprint..

A great many who send blue prints to the Bunting Brass & Bronze Company have in mind things not shown by the drawings. They know that in the event of an unforeseen happening of any kind they can depend on the Bunting organization for consideration, cooperation and prompt, specific help. Ask any Bunting customer.

The sleeve bearing is not complex in structure; it conforms readily to design requirements, it is easily installed. Cast Bearing Bronze is the most adaptable of all sleeve bearing materials, it possesses excellent anti-friction properties. With proper film lubrication, its coefficient of friction is as low as can be obtained with any other bearing type. A successful Bunting Bronze bearing installation is readily attainable. We ask the opportunity to work with you, and to quote on your requirements.

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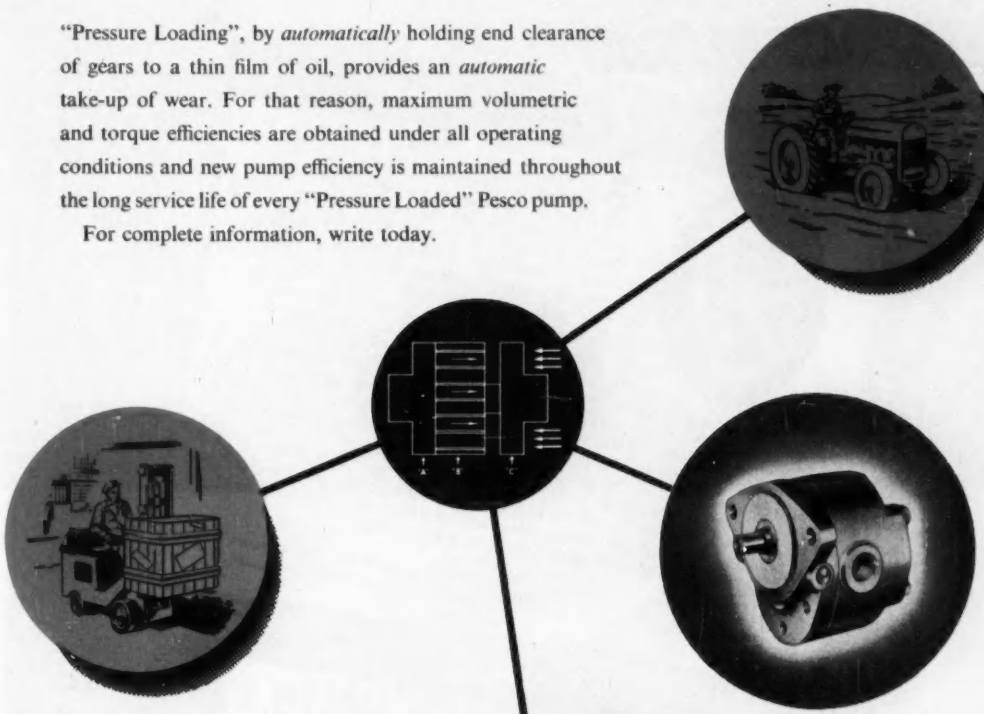

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Great names in the Automotive Industry

BENJAMIN BRISCOE

Benjamin Briscoe was already a successful sheet metal manufacturer when the automobile caught his fancy and with his brother, Frank, he put up $100,000 to help finance building the first Buick car. In 1903, Briscoe formed a partnership with Jonathan Maxwell and when additional capital was needed, he got it from New York bankers, thus becoming the first man to interest Wall Street in the automobile industry.

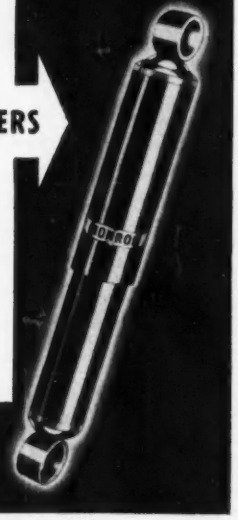
In 1908, a plan to merge Maxwell-Briscoe with Ford, Oldsmobile and Buick fell apart and Briscoe launched his own United States Motors Company. At one time this organization embraced 150 companies and sponsored 28 models under 7 different brand names, but misfortune overtook the enterprise and it crashed in 1912.

Briscoe tried again in 1913, with the Briscoe car. He converted to arms production in World War I, during which he served in the U. S. Navy as a Lieutenant Commander, winning the Navy Cross. In 1938, Ben Briscoe retired to Florida where he died in 1945.

(One in a series of sketches about great automotive industry pioneers. These have been compiled in book form and are now available on request.)

MONROE—THE GREAT NAME IN SHOCK ABSORBERS

Together with better highways, improved ride control devices have greatly smoothed travel for America's autos, trucks and buses during the last half century. Monroe has pioneered in developing the best ride control products—shock absorbers, sway bars, struts and molded rubber parts. Today, Monroe ride control products are top choice among America's automotive engineers.



MONROE®

Monroe Shock Absorbers are standard equipment on more makes of new cars than any other brand of shock absorber.

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A sage once said "Take care of the little things, and the big things will take care of themselves." Not entirely true. But there's a great deal of common sense in the thought. We, at Spicer, subscribe to it in principle and in practice.

Spicer is big. Big in our way of thinking. Big in our way of producing. Big in our way of watching what's going on. From the engineering department to the shipping platform, we pay attention to the little things... because we know they mean big things to you.

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The designing and manufacturing skill gained from producing millions and millions of Spicer units is used by a majority of manufacturers in the truck, bus, tractor and passenger car fields. These Spicer products are built in modern plants that employ the industry's most advanced production-equipment and techniques. Spicer . . . and Spicer alone . . . offers you a complete range of products covering every need in the automotive power transmission field. Look to Spicer for assistance that perseveres all the way from the drawing board through to service in the field.

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ARE AVAILABLE IN

1. Air-Over-Hydraulic

or

2. Straight Air

SYSTEMS

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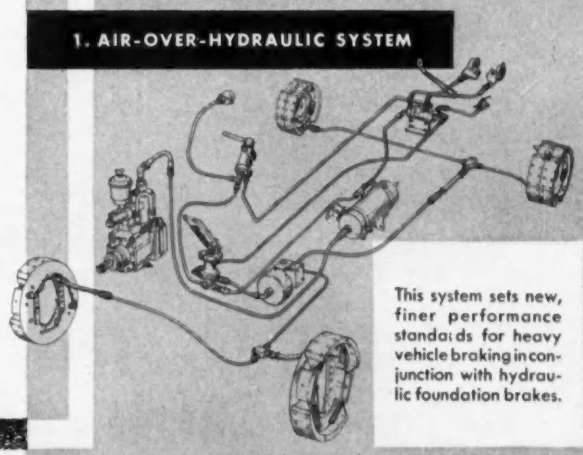
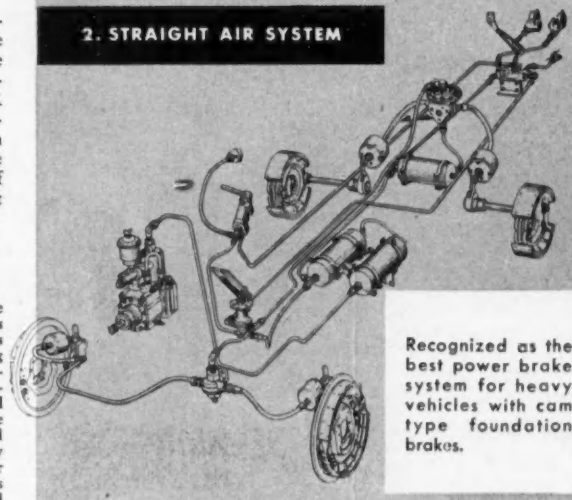


This system sets new, finer performance standards for heavy vehicle braking in conjunction with hydraulic foundation brakes.

2. STRAIGHT AIR SYSTEM



Recognized as the best power brake system for heavy vehicles with cam type foundation brakes.

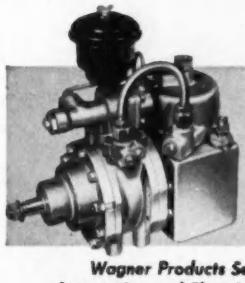
Used as original equipment by truck and bus manufacturers!

These two types of Wagner Air Brake systems offer many operating advantages. The STRAIGHT AIR system for cam type foundation brakes provides plenty of controllable power and the AIR OVER HYDRAULIC system combines many advantages that result in a material reduction in maintenance and operating costs. These Wagner systems meet the requirements of all types of vehicles and assure highest braking efficiency.

ALL WAGNER AIR BRAKE SYSTEMS HAVE THE ROTARY AIR COMPRESSOR

In every Wagner Air Brake System you get the famous Wagner Air Compressor, known for its long life, dependability and high efficiency. It is of the *Rotary* type—thousands of small overlapping air compression impulses occur per minute assuring an abundance of air under all operating conditions. Simple in construction, easy to install and repair, the Wagner Rotary Compressor will give years of dependable service and provide real economy in Preventive Maintenance. It will pay you to investigate the many advantages of Wagner Air Brakes as standard equipment on the vehicles you manufacture. Get complete information and copy of Catalog KU-201. Coupon is for your convenience.

Wagner Air Brake Users are our Biggest Boosters!



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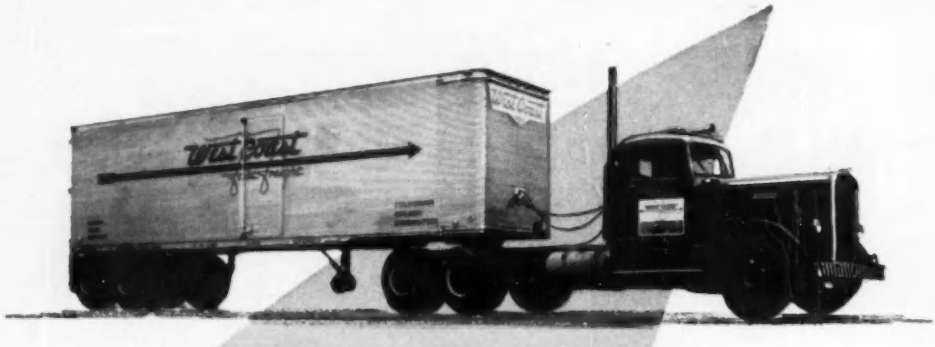

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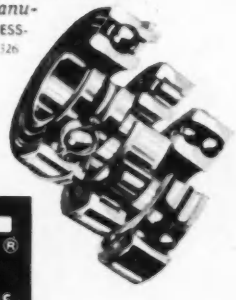
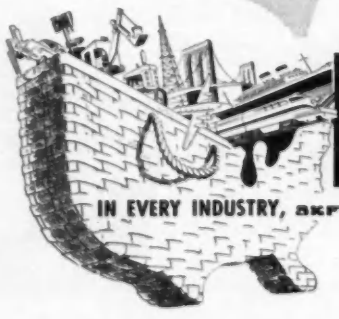
It may be thirty below zero or a hundred and fifteen above—every day, almost a thousand West Coast Fast Freight trucks are covering California, Oregon, Washington, Idaho, Montana, travelling seven thousand miles of highway with general commodities. Their average load rolls 721 miles in a twenty-four-hour-a-day operation. The fact that West Coast rigs deliver the goods under tough conditions is a tribute to operating wisdom, and to good equipment well maintained. For this maintenance, West Coast depends on SKF Bearings. They've learned that, where endurance and dependability are essential, they can depend on SKF.

Designers of heavy-on and off-the-road automotive equipment know these SKF Bearings well. They depend on SKF Single Row Deep Groove Bearings for their ability to sustain combined radial and thrust loads at high speed, for their available combinations of shields and seals which exclude dirt and retain lubricant. They depend on SKF Cylindrical Roller Bearings for extremely high radial capacity and low friction which perform so well at high speed. And for propeller shaft boxes on heavy duty equipment, designers specify SKF Self-Aligning Ball Bearings. The teamwork of automotive equipment designers and SKF engineers always produces advanced, dependable equipment. **SKF INDUSTRIES, INC.,** PHILADELPHIA 32, PA. — *manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.* 7126





SKF®
BALL AND ROLLER BEARINGS

IN EVERY INDUSTRY, SKF Puts The Right Bearing In The Right Place

HAVE YOUR FASTENING METHODS

kept pace?

It's a long way from prairie schooners to the sleek, comfortable family cars of today. And design changes never stop. That's why it pays to have your fastening methods checked by trained specialists . . . constantly.

United-Carr offers you • Complete engineering and design service • Complete facilities for volume production of specialized fasteners and allied devices • Wide experience with the top manufacturers of automotive equipment, aircraft, electronic equipment, appliances, furniture • The varied technical knowledge of all our divisions and subsidiary companies combined . . . to help you cut costs, speed assembly, improve product performance.

Call your nearest United-Carr field engineer *before* your new designs crystallize. It is in this all-important *planning* stage that you can make the most effective use of our special services.

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UNITED-CARR FASTENER CORP., CAMBRIDGE 42, MASS.

TAILOR-MADE IN VOLUME QUANTITIES

KLIXON
Circuit Breakers
Fly WITH...

...United Air Lines New Convairs

United's new Mainliner Convairs embody the latest developments in aircraft efficiency, dependability and passenger comfort. These Convairs are faster, carry greater payloads and have increased cruising range.

To guard the miles of electrical circuits in these skybirds, Klixon D6751-1 trip-free, push-pull Aircraft Circuit Breakers are used. These lightweight, compact Klixon Breakers stand ready to trip-out the circuit should overloads or shorts jeopardize the electrical system. As soon as the trouble is remedied, the pilot or co-pilot reestablishes the circuit by pushing a button.

Klixon Breakers are unaffected by shock, vibration, altitude, motion, regardless of the mounting position. Harmless transient shorts do not cause nuisance breaks.

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Leading Producer of Wheels for Every Purpose, Offers . . .

STYLE-PERFECTED WIRE WHEELS!

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Skillfully designed! Radically improved over former American types, or even present-day importations! A major achievement to greatly enhance a modern car's entire appearance of custom styling, for those to whom pride of ownership is all important! Wheels of superior strength, safety and brake-cooling action, as well as for arresting distinction!

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KELSEY-HAYES WHEEL COMPANY

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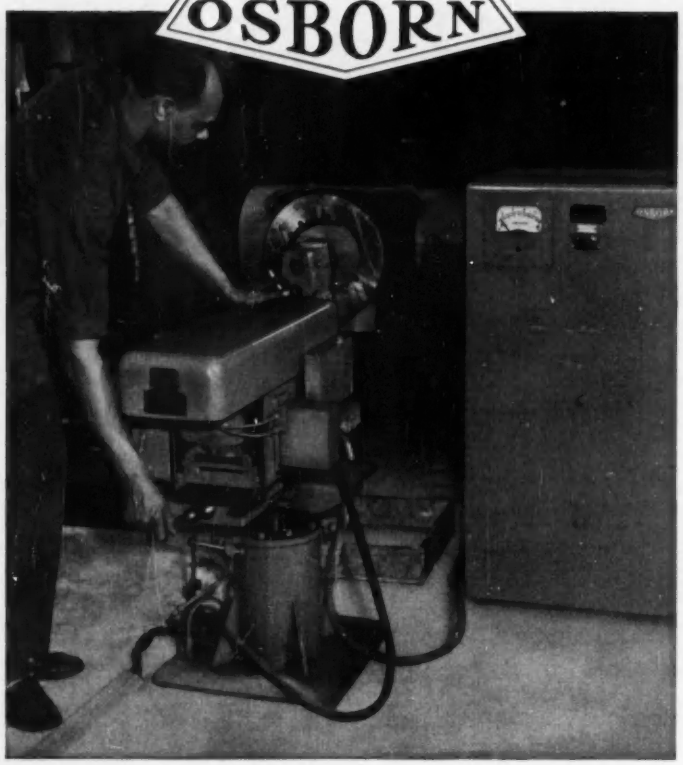
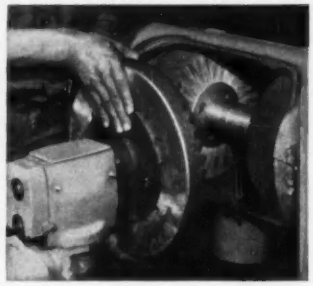
PRODUCTS: Wheels—Hub and Drum Assemblies—Brakes—Vacuum Brake Power Units—for Passenger Cars, Trucks, Buses—Electric Brakes for House Trailers and Light Commercial Trailers—Wheels, Hubs, Axles, Parts for Farm Implements.
PLANTS: Kelsey-Hayes Plants in Michigan (4), McKeesport, Pa., Los Angeles, Calif., Davenport, Iowa, Windsor, Ontario, Canada.

OSBORN



SET-UP IS SIMPLE. The machine is versatile. If your production involves small runs of many different types and sizes of gears and similar parts, you can specify machine settings for each part and operator can make set-up changes easily and quickly for maximum daily output. The complete brushing cycle is controlled automatically by the electronic timer which is set for any desired brushing interval to suit the size, shape or condition of part being brushed.



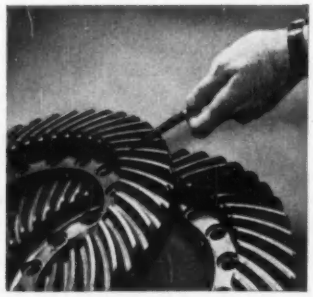
OPERATION IS SPEEDY. The operator mounts the gear easily and quickly. The gear advances to the face of two rotating Osborn brushes and the edge of the gear teeth makes contact with the brushes. To assure fast, positive action on each piece brushed, an automatic control reverses the direction of brush rotation on every cycle of operation.

Deburrs gears 15 times faster at the push of a button!

Want to break a big bottleneck in the production of gears and similar parts? Manufacturers are doing just that with the Osborn Work Holder Brushing Lathe.

In the plant of the White Motor Company, Truck Division, Cleveland, Ohio, this Osborn machine deburrs and finishes gear teeth 1570% faster than the old method. This was done formerly with a portable grinder . . . a tedious operation that took 25 minutes for the 14-inch hypoid gears shown. Now, an operator simply places the gear in the Osborn Work Holder Brushing Lathe, pushes a button and the machine does the job automatically. Floor-to-floor time is only 1½ minutes! Uniformity of finish results in additional time savings in matching and assembly of gears.

It will pay you to investigate this high-speed, high-quality machine for deburring and finishing gears on a production basis. Call your **O**sborn **B**rushing **A**nalyst today or write *The Osborn Manufacturing Company, Dept. 919, 5401 Hamilton Avenue, Cleveland 14, Ohio.*



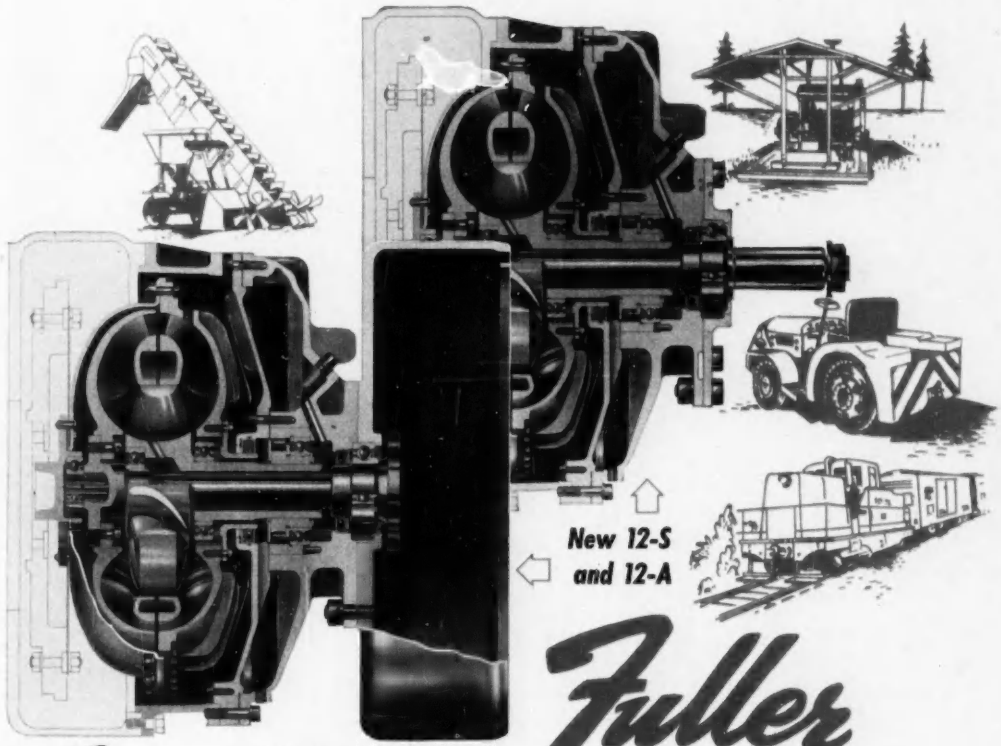
RESULTS ARE UNIFORM. Burrs and sharp edges are removed uniformly. Every gear tooth has smooth, uniform rounded edges. Surfaces are blended.

INVESTIGATE IT TODAY

for *your* problems. Users report time savings ranging from 20% to 1570% with the Osborn Work Holder Brushing Lathe. Let us demonstrate what it can do for you!

Osborn Brushes

OSBORN POWER, MAINTENANCE AND PAINT BRUSHES AND FOUNDRY MOLDING MACHINES



Fuller Torque Converter Couplings

Designers now have at their command a new torque converter coupling for engines delivering maximum torque of 180-225 foot pounds. Fuller's new 12-A and 12-S converter coupling drives have proved highly successful in delivery trucks, fork-lift trucks, tow trucks, hoists, locomotives, loaders and other installations where start-and-stop, heavy load pickups are hard on engine, gears, drive lines, axles and tires, and tiring on operators.

Design these advantages into *your* new equipment.... 2.1 to 1 torque multiplication .... elimination of shock loads and stalling .... greater operator ease.

Available with *splined* output shaft (12-S) or with *flanged* output shaft and SAE No. 3 flywheel housing (12-A). Multiplication 2.1 to 1 at stall for smooth starting and hard pulling. Stator mounted on over-running clutch which permits automatic change to fluid coupling operation for economy in normal running. Maximum diameter of fluid circuit 12¾". Designed for engine speed of 2000-2200 and higher.

Ask for an analysis by our engineering department for *your* application, giving engine torque and hp. curve.

- SPEEDS WORK
- SMOOTHS POWER
- PREVENTS SHOCK
- PLEASES OPERATORS
- PRESERVES EQUIPMENT

Fuller TRANSMISSIONS

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CLARK

THE Split-Pin Synchronizer

featuring

SIMPLICITY
RUGGEDNESS
DEPENDABILITY

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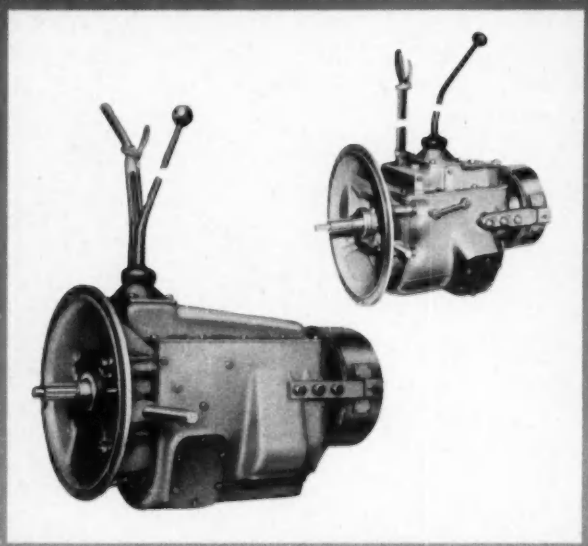
CLARK Transmissions

Applying imaginative enthusiasm for engineering development to the practical solution of production needs is as typical of Clark Equipment as the trade mark. This combination of vision and practicality will continue to produce a full range of conventional transmissions. It will also continue to produce transmissions for specialized, unusual requirements . . . for trucks, buses, farm tractors, industrial trucks and road building machines.



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FORK TRUCKS & TOWING TRACTORS GEARS & FORGINGS

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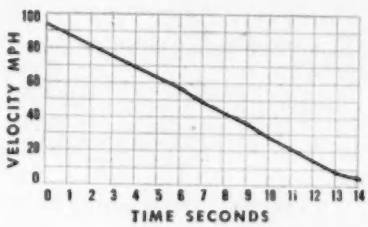
How to absorb 25 million FT-LBS of energy in 1000 feet!

This deceleration chart shows what happens when a pilot brings his 20 ton ship in for a landing. During this stop, terrific heats and pressures are created. Yet planes must stop safely... and quick!

American Brakeblok attacked this problem during World War II. Working closely with aviation brake manufacturers we developed the formulas to do the job. We helped solve some very difficult manufacturing problems, created mass-production methods and equipment.

Today we are a major supplier of aviation brake lining. Our research laboratories, manufacturing facilities and years of experience are ready to serve—either for military or civilian needs.



American Brakeblok

THE SAFETY BRAKE LINING

AMERICAN Brake Shoe COMPANY

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AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

SPOKE WHEELS

. . . Standard on FORD F-7 and F-8 "Heavies"

In building "Big Job" trucks that give long, dependable hauling service, Ford engineers specify spoke wheels as standard equipment. These sturdy lightweight wheels are made to stand the gaff of full pay-load operation. One reason . . . they're constructed of rugged cast steel. Another . . . the spoke design provides better ventilation . . . carries off more of the heat that arises from hard-working brake drums.

• Spoke wheels reduce "down time" . . . provide faster tire changes on tight schedules . . . assure minimum unsprung weight . . . and cut per mile operating costs. Be sure your new Ford F-7 or F-8 is equipped with spoke wheels. They're standard at no premium in price.

The spoke wheels used by Ford are made by Gunite Foundries Corporation . . . a leader in the development of superior metals and metal products since 1854.

GUNITE REAR TRUCK WHEEL

GUNITE

GUNITE FOUNDRIES CORPORATION, Rockford, Illinois

Just turn the ignition key and you're ready to go—that's the new and convenient way of starting. And best of all, switch key starting, like most starting systems, costs less with Bendix* Starter Drive. This unique combination of convenience and low cost is made possible by Bendix exclusive design features. For example, the Bendix Starter Drive requires no actuating linkage and the solenoid may be placed in any convenient position. Result—starting motor can be mounted more easily and in more positions. Also, the Bendix Drive has fewer parts and needs fewer adjustments. If you want true economy from installation to service, plus performance proven by over 85,000,000 installations, be sure to specify Bendix Starter Drives. Your inquiry will receive immediate attention.

*REG. U.S. PAT. OFF.

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ELMIRA, NEW YORK

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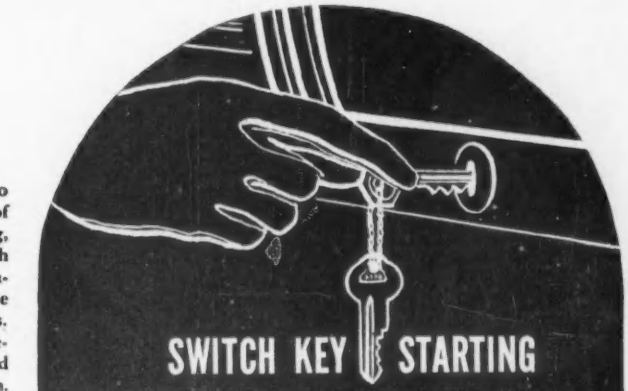
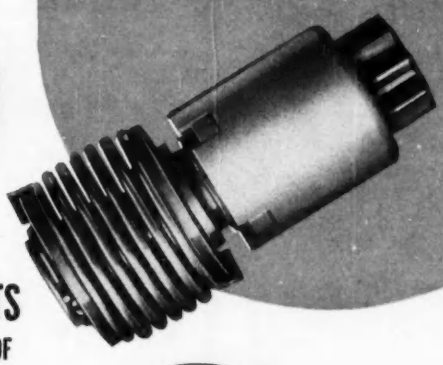


SWITCH KEY STARTING

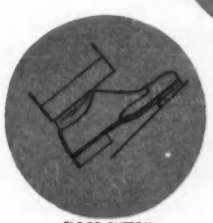
COSTS LESS

WITH Bendix

STARTER DRIVE



PUSH BUTTON

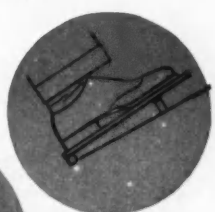


FLOOR BUTTON

SPECIALISTS IN ALL TYPES OF STARTING!

SWITCH KEY

CLUTCH PEDAL



ACCELERATOR

Our Engine Bearings are specified as original equipment by the leading names in motordom because they have consistently contributed to better performance for more than a quarter century.

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Ford
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DETROIT ALUMINUM & BRASS CORPORATION
DETROIT 11, MICHIGAN

How Much Freight
Will They Carry in 1962?
It's big, brawny and still growing, this trucking industry of the U.S.A. It hauls more than eight billion tons of freight a year... a total certain to increase in the next decade with improved truck performance and greater payloads.
These trucks of tomorrow are in the design stage *now*. So are the many Campbell, Wyant and Cannon castings which will increase engine life and improve performance... castings with even greater strength, more resistance to wear and better machinability.
CWC has long pioneered in foundry techniques... in advanced metallurgical engineering, precision control and mechanized production. These are the important reasons why this foundry is so often called to help manufacturers in the truck field, as in many others, to plan for tomorrow's castings of highest quality at lowest cost.
CAMPBELL, WYANT AND CANNON FOUNDRY COMPANY
MUSKEGON, MICHIGAN
Foundries in Muskegon, South Haven and Lansing, Michigan
... serving the automotive, farm equipment, railroad and marine industries and the Armed Forces
CWC
Since 1908
CAST CYLINDER HEADS AND BLOCKS
CAST PISTONS
CAST CAMSHAFTS
CAST GEARS
CAST CRANKSHAFTS
CENTRIFUGALLY CAST CYLINDER LINERS
CENTRIFUSE BRAKE DRUMS

Triple-alloy steels containing nickel offer designers the following *triple* advantages:

1. OUTSTANDING PERFORMANCE—Strength and toughness, resistance to wear, fatigue or shock to meet a wide range of requirements, as dictated by design.
2. RELIABILITY—based on consistently uniform response to heat treatment.
3. ECONOMY—resulting from standard compositions precisely graded to match the engineers' needs.

Service records established by triple-alloy steels over a period of years show that they are giving excellent results in many diverse and exacting applications.

The many standard combinations available permit accurate and economic selection for specific uses.

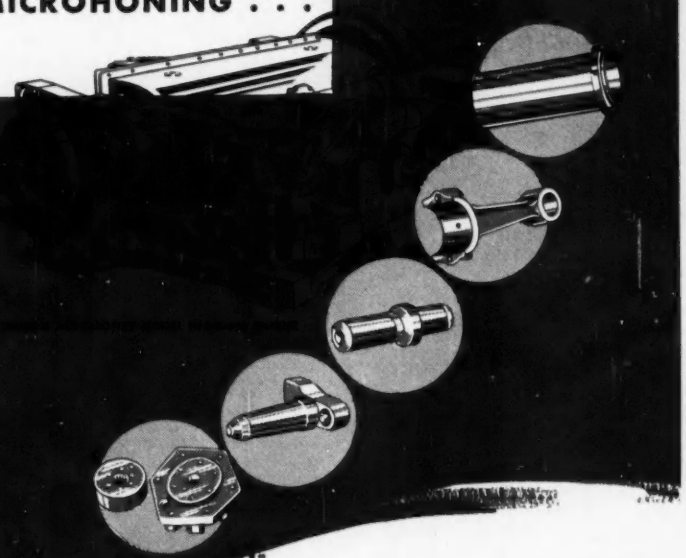
Because of their many advantages, these triple-alloy steels warrant your careful consideration when planning new or improved designs. We shall be glad to furnish counsel and data upon request.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

INCREASED EFFICIENCY OF

DIESEL ENGINES

THROUGH MICROHONING . . .



PRECISION PRODUCTION THROUGH MICROHONING
MICRO MATIC

Diesel engines are chosen because of their dependable low cost power. The more precise the fit of parts, the more efficient the engine.

MICROHONING gives to functional surfaces of

- cylinder liners
- connecting rods
- valve guides
- injector barrels
- pump discs . . .

accurate size, true geometry, and the characterized finish—all at production rates.

For Information on MICROHONING of DIESEL ENGINE PARTS
Write for
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MICROHONING = STOCK REMOVAL + GEOMETRY + SIZE CONTROL + SURFACE FINISH

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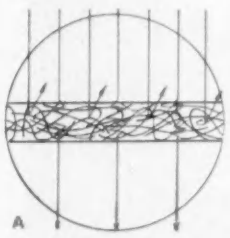
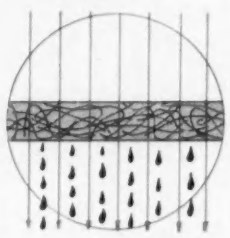
How tracing paper is made and why ALBANENE* is Different

TOUGH, LONG-FIBER PAPER
NOT TRANSPARENTIZED



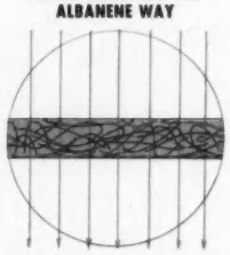
Diagrammatic enlargement of cross section of paper with high strength but low transparency. Fibers are surrounded by air, which has different index of refraction. Many light rays are bent back and do not get through.

SAME PAPER
TRANSPARENTIZED WITH FLUID MATERIAL



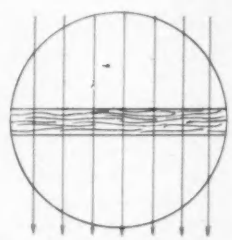
Same paper as "A", filled with oil or other fluid material, giving spaces between fibers same index of refraction as fibers. Reflection and refraction of light are reduced and paper becomes highly transparent. But transparency is not permanent because *fluids* "bleed" out.†

SAME PAPER
TRANSPARENTIZED THE ALBANENE WAY



Same paper as "A", filled with an inert synthetic resin, with correct index of refraction. This is how Albanene is made. Its transparentizer does not "bleed" out. Albanene holds its color and strength and is permanently transparent.†

PAPER TRANSPARENTIZED BY
CRUSHING AND BEATING FIBERS



Papers are also transparentized at the mill by a "beating" process. The fibers are crushed, flattened and compacted. Reflection and refraction of light are reduced. But the process weakens the fibers and the strength of the transparent paper is low.

More than 15 tests are made during production of Albanene. For example, each production roll is tested for pencil "take", for pencil erasing and the taking of drawing ink. To eliminate human variables, pencil lines are drawn by machine. In this way you are assured of the uniformity of working surface so much desired by draftsmen, and assured of a paper that makes cleaner, sharper prints . . . now or a gen ration later. Ask your K&E Distributor or Branch for further information.

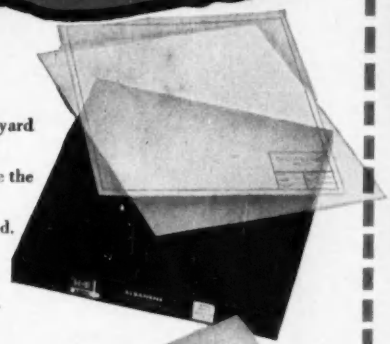
† Prove this by making the "drafting tape test" Press a short piece of drafting tape on fluid-transparentized paper, and another on Albanene. Strip them off the next day and examine both papers. Notice that enough fluid has drifted out of the ordinary paper into the tape to destroy much of the transparency. And notice that Albanene is not affected. What drafting tape does over night, time will do naturally.

*TRADE MARKS ®

Transparent... and Better!

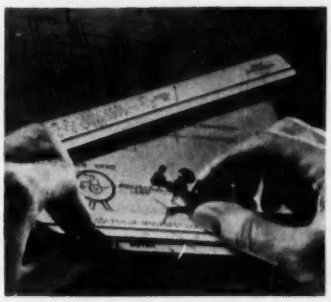
AVAILABLE IN MANY FORMS FOR MANY USES

Albanene comes in 20-yard and 50-yard rolls in various widths and in three different weights. For those who like the convenience of cut sheets, a new Albanene package has been designed. It strongly protects the paper in shipment and storage, and may be opened without mutilating the container, thus serves as a dispenser in drafting room or stock room. Albanene cut sheets can be supplied imprinted to your specifications.



The Right Angle

Once you've discovered the pleasure of drawing on Albanene, the next logical step is to save time, trouble and eyesight with a K&E PARAGON® Drafting Machine. You control your calibrated straight edge with a light touch of one hand, for parallel lines and lines at any angle.



Make your lettering letter-perfect and save wear and tear on your nerves by using a LEROY® lettering outfit. Template grooves guide your pen so the finished result looks like printers' type, and the whole process is relaxing. There's a wide choice of sizes, styles and symbols.

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New source of plastics for the automotive industry

at United States Rubber Company's Chicago Die Mold plant

One of the 40 Plunger Transfer and Compression presses in U.S. Rubber's new Chicago Die Mold Plant.

This is the newest unit in the nationwide chain of plants and laboratories which comprises United States Rubber Company.

This modern new plant houses the productive facilities and scientific personnel for wider excursions into the field of plastics, in the form of moldings, extrusions and fabrications.

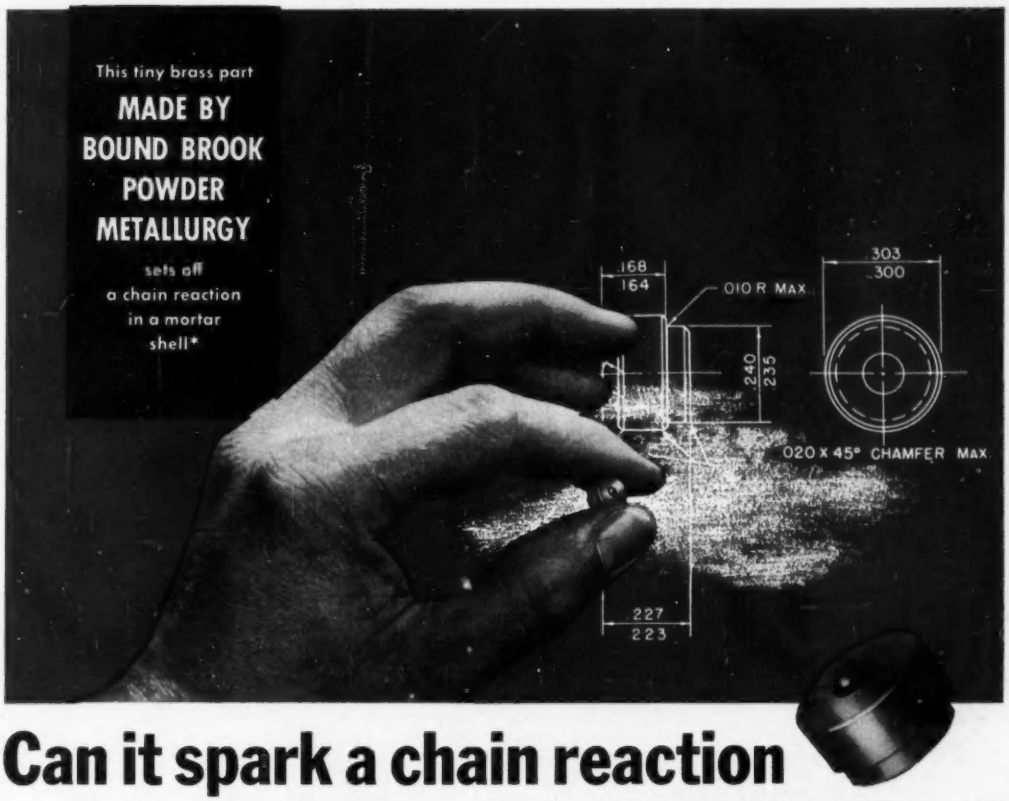
For the automotive industry, this plant will produce plastics molded by injection and compression (transfer or plunger). It has its own mold manufacturing facilities. The equipment is of the most advanced type, and the engineers have at their command the great research stockpiles of the United States Rubber Company. This Chicago Die Mold Plant will supplement the "U.S." plant and laboratory at Fort Wayne serving the automotive industry.

Other equipment in the plant includes 20 Injection Machines, with controlled mold temperatures.

PRODUCTS OF U.S. RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.



Can it spark a chain reaction in your future product planning?

It's time to take a second look at the multitude of brass parts you've been machining—or having machined—from bar stock! And at the other brass parts you've had made as forgings, stampings or investment castings!

Brass parts are now being made by the million *from metal powders—by Bound Brook skill.* Made without costly, time-consuming machining. Made to finished size and shape, with all critical dimensions held within close tolerances.

Bound Brook brass parts are currently being extensively used in ordinance applications where extreme accuracy is necessary. And frequently, as in the case of this tiny firing pin, quality control limits are extremely tight—.65AQL in this instance.

That combination of accuracy and low cost is worth looking into for civilian applications too, isn't it? We'll be glad to send you preliminary information on brass parts by Bound Brook—or to get right down to cases on specific applications.

*This firing pin used in mortar shells actuates the percussion primer, which in turn sets off the propellant charges. Explosive charge in the shell is detonated when the shell strikes its objective. Accuracy of the firing pin is essential to the entire sequence of operation.

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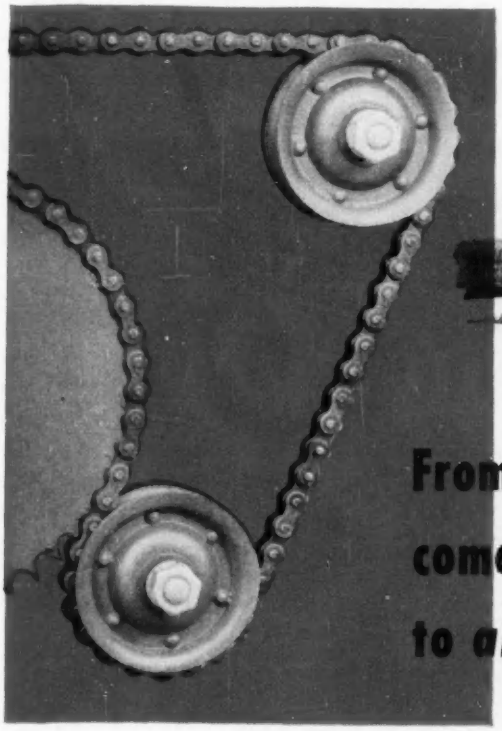

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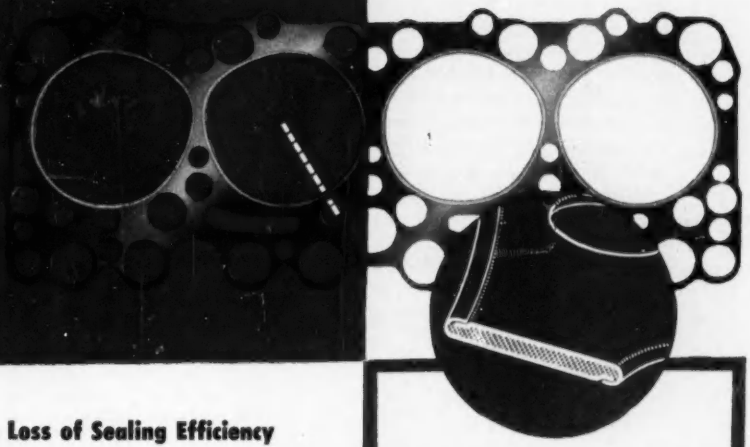

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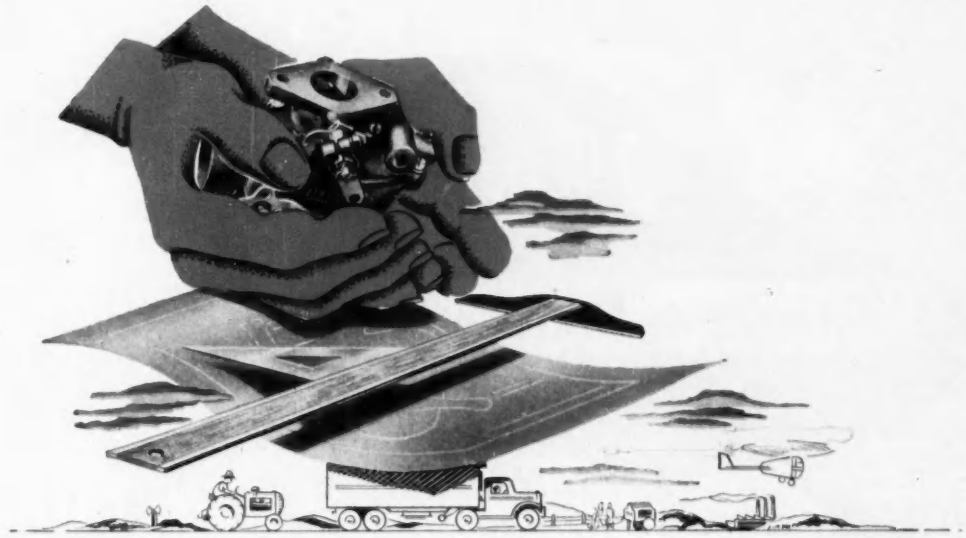

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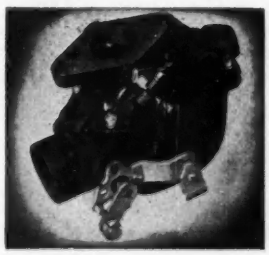

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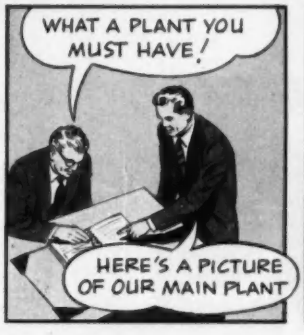

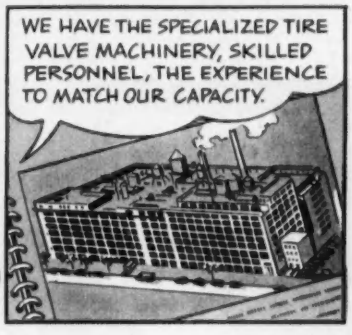

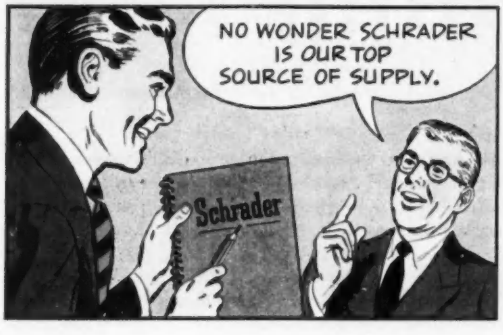

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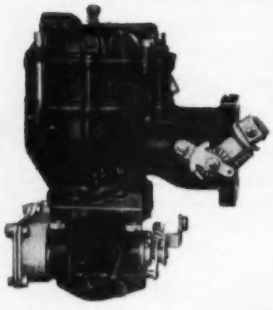

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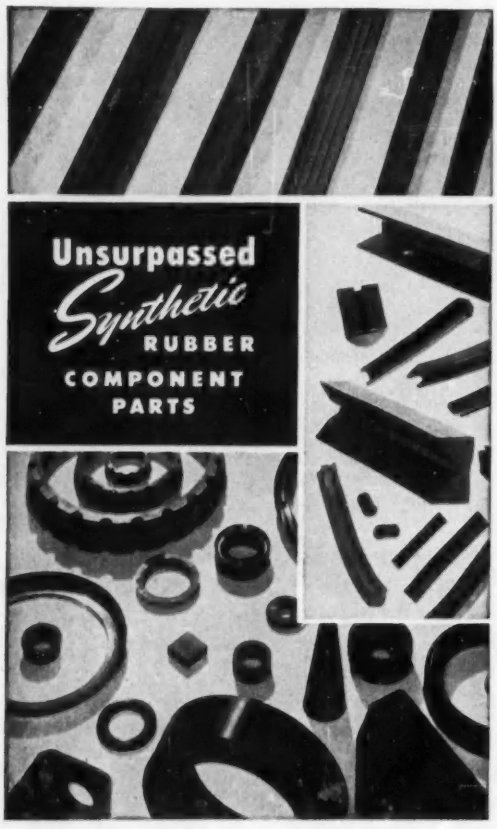

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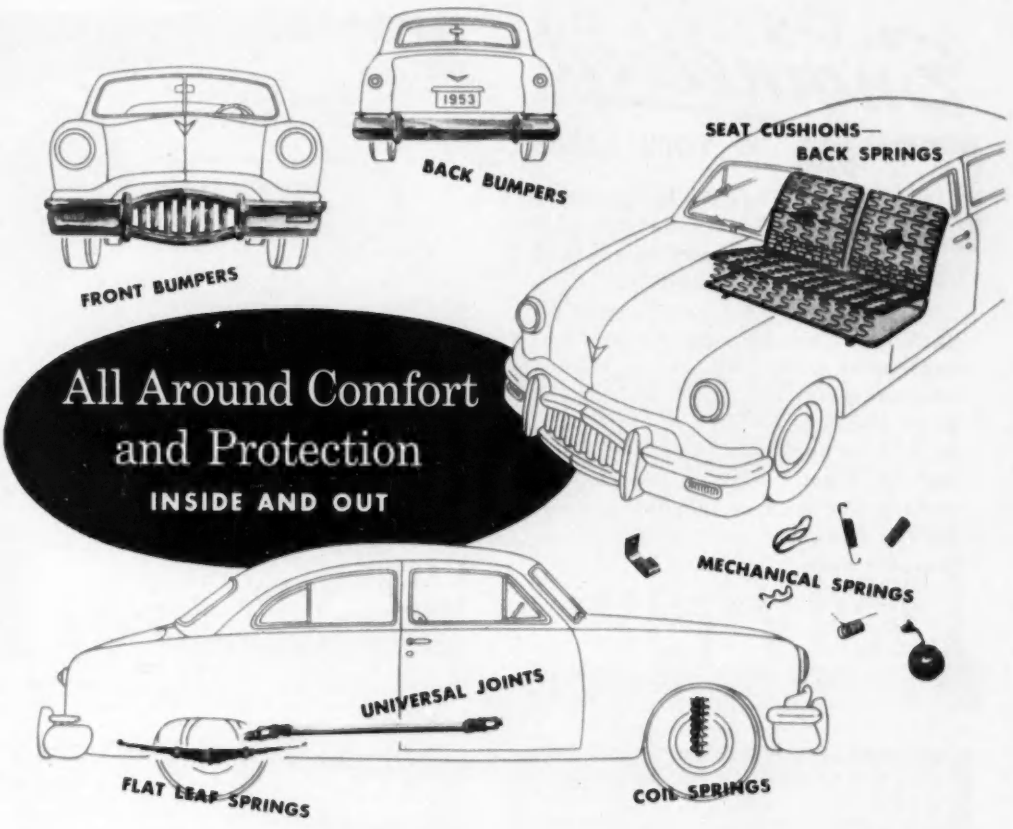

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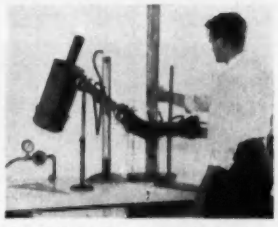

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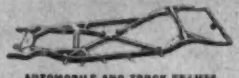
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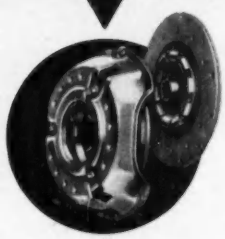

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